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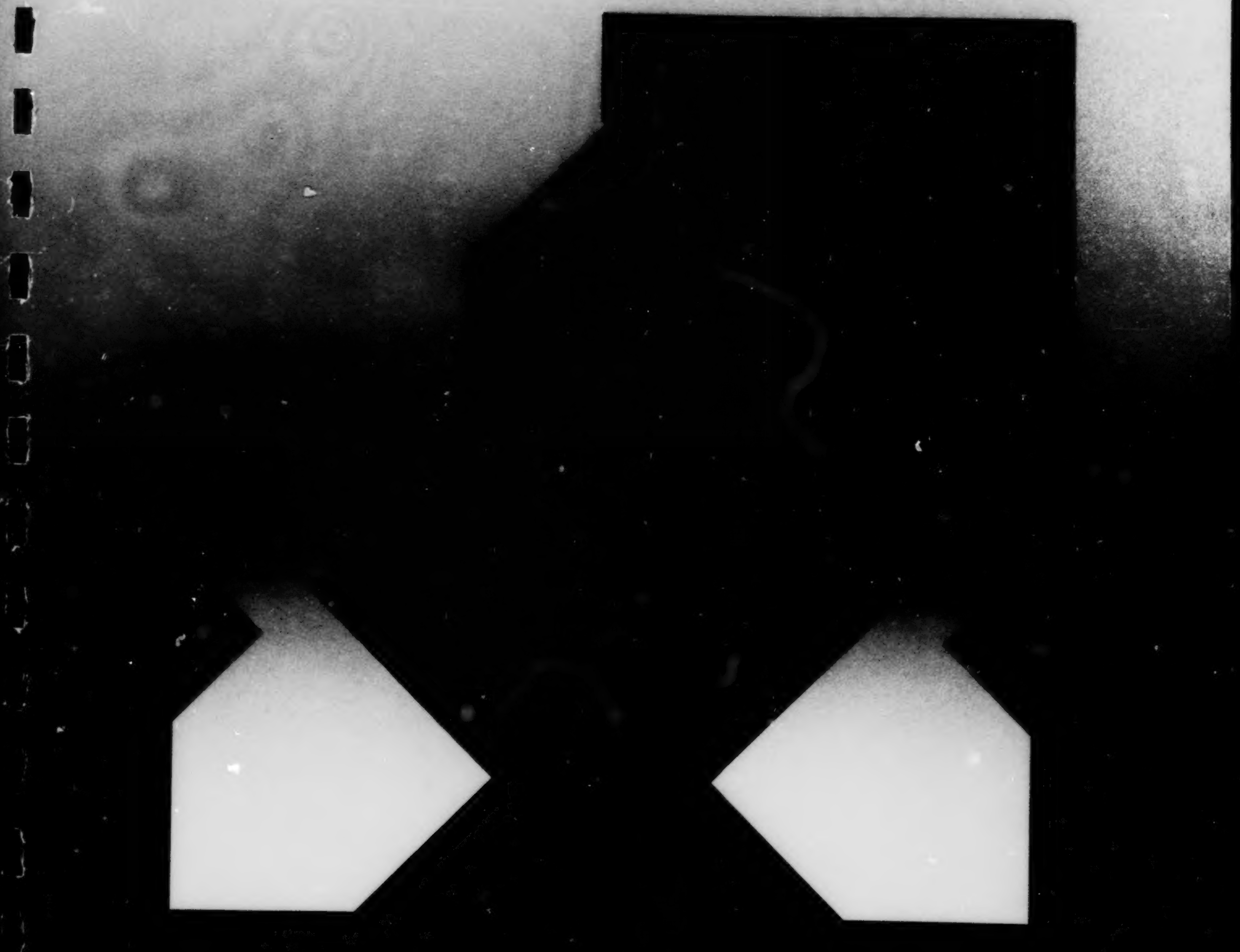

Canada

DEVELOPMENT OF AN INTEGRATED HEATING AND VENTILATION SYSTEM

JANUARY 1991

DEVELOPMENT OF AN INTEGRATED HEATING AND VENTILATION SYSTEM
FINAL REPORT

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SIRICON, January 1990

92-07134/

Canada Mortgage and Housing Corporation, the Federal Government's housing agency is responsible for administering the National Housing Act

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ACKNOWLEDGEMENTS

CMHC gratefully acknowledges the contribution of Augustin Brain in the preparation of this report and Les Industries Dettson for their technical assistance and contributions to the project.

NOTICE TO READER

This project was designed to develop an integrated heating and ventilation system in accordance with Preliminary Standard CSA F326 Requirements for Mechanical Ventilation - May 1988.

Since that time, CSA F326 has gone through a number of changes that are not reflected in this project or the design. The simplifications reflected in the most recent version of the standard may provide opportunities for simplification of the design presented in this report. Nonetheless, the approach and data collected in this project provides valuable information that will help to direct the development of appropriate technologies to facilitate compliance with CSA F326.

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EXECUTIVE SUMMARY

An integrated heating and ventilation system was designed to comply with the requirements of proposed standard CSA F326 Residential Mechanical Ventilation Requirements - May 1988. In summary the system was designed to address the following issues:

1. supplying sufficient outdoor air to rooms
2. tempering outdoor air
3. integrating make-up air with exhaust fans
4. managing air flows and pressure imbalances.

An air management system was developed as part of an integrated heating and ventilation system. The air management unit modulates the supply of fresh air when exhaust fans are operated so as to maintain adequate ventilation to the house, maintains a balance of pressures in the house and optimize make-up air demand. The integrated system is under the control of a microprocessor device which controls the operation of the ventilation system and heating system.

Flows are manually adjustable up or down by means of a control unit to satisfy the occupant's needs. The system is also adjustable to meet the minimum continuous air flows required by codes and standards for houses of varying volumes.

A custom designed differential pressure sensor was developed by the manufacturer and the the output of the sensor is interfaced to damper in the mixing box. Pressure control is achieved by reducing the system exhaust flow(ON/OFF control of the system exhaust fan) and/or increasing the system fresh air intake by modulating the mixing-box damper which opens the vane for the make-up air opening, and/or by increasing the circulating fan speed (thus the return suction). In circumstances where the recirculation system is unable to provide enough suction to satisfy ventilation or make-up air requirements, a supply fan can be used to augment the fresh air flow. In this case, it may be appropriate to consider heat recovery. This approach was used in this project.

The monitoring program demonstrated the systems ability to satisfy each of the key criteria defined by the CSA F326 Standard. The most challenging aspects of the project were the systems ability integrate make-up air and exhaust fans so as to manage pressure imbalances caused by the operation of the exhaust fans.

The challenge to managing pressure imbalances was to define a reliable outdoor reference pressure. Two approaches were evaluated. The first approach utilized conventional practice of installing pressure taps on each outdoor face of the building and connect these through a pressure averaging box to minimize pressure changes due to random fluctuations in wind.

The second approach utilized a single pressure tap in the attic.

It was found that the conventional practice of measuring the outdoor reference pressure using a pressure tap on each face of the house was an ineffective method of averaging pressure imbalances across the envelope caused by fluctuations in wind. The reference point in the attic proved to be a much more effective and practical location for measuring the outdoor reference pressure.

While the pressure sensor approach combined with an attic reference proved to be an effective approach, the system operation was complicated by stack pressure in excess of 5Pa. It was assumed in the project that the goal was to provide make-up air for conditions where the incremental pressure(in excess of stack) exceeded 5Pa. The pressure sensor was unable to distinguish between exhaust fan induced pressure increases and stack and wind induced increases. An alternative approach utilizing the status of exhaust fans was found to be a more reliable method of sensing critical pressure imbalances.

The application of pressure sensing devices needs to be explored further. Areas of further research should include sensor ability to be able to distinguish between fan induced and stack and wind induced pressure increases; and the determination a suitable location for the outdoor pressure reference location. Dampening of fluctuations in pressure differential caused by random fluctuation in wind also needs to be explored further.

The approach that monitors the status of some or all of the exhaust fans is considered a more reliable method of sensing potentially critical pressure imbalances. This approach is not influenced by wind or stack. However, this method has the added complication of requiring an estimation or measurement of the building envelope tightness.

The system developed for this project was demonstrated to effectively combine space heating, domestic hot water heating and ventilation into a single integrated system. Further the system was shown to be able to effectively manage pressure imbalances in response to an input signal that indicated an unacceptable pressure imbalance.

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1.0 INTRODUCTION

1.1 BACKGROUND AND GENERAL DISCUSSION

The trend towards energy efficient housing is being tackled on several fronts including increased wall insulation values, more energy efficient heating systems and appliances, and increased levels of airtightness. The latter, is of particular concern because, despite significant increases in comfort and reductions in heating bills, increased levels of airtightness can virtually eliminate the natural entry of fresh air (through air leakage) and the removal of stale air. As a result, home builders and designers must now build into the mechanical design of the building some means of providing adequate ventilation to maintain good air quality.

In energy efficient houses of recent design, packaged balanced ventilation systems have been the primary means to achieve this goal. Despite the ability of these systems to provide the required ventilation rates to houses and meet a very real need for controlled ventilation, they do not resolve the problems of combustion backdrafting and spillage in naturally aspirated heating appliances and fireplaces that are caused by competition with other exhaust appliances such as central vacuums, dryers and indoor barbecues to name a few.

Over the past few years, several major research studies, computer models, field investigations and publications have been completed in this field. Despite the wealth of knowledge derived from these efforts, builders are still frustrated as to what type of system will satisfy all the requirements of air quality, ventilation and combustion safety. Similarly, building inspectors are finding it increasingly difficult to measure the compliance of ventilation systems with regards to current code requirements. Thus, there is a need to interpret all the accumulated knowledge in this field in a language easily understood by the builder, homeowner and building inspector.

The vehicle for changing this situation may be field demonstration of integrated heating and ventilation systems that directly address the requirements of air quality, ventilation and combustion safety. The impact of a breakthrough in this field may reach farther than just new super energy efficient houses but to a larger emerging renovation market.

1.2 PROJECT OBJECTIVE

This is a joint project involving les Industries DETTSON Inc., CMHC and SIRICON. The financial contribution from DETTSON was focused on the development of the system while that of CMHC was focused on monitoring with an emphasis on the F326 DSA draft standard and on data analysis. No CMHC funds were applied to system development.

The objectives of the project are as follows :

1) to complete the development of an integrated residential heating and ventilation system that addresses the issues of air quality, ventilation and combustion safety in compliance with the proposed standard CSA-F326.1 (category I Fuel-Burning appliances)

2) to construct a prototype system appropriate for installation and demonstration in an actual house

3) to develop a comprehensive monitoring program to evaluate the performance of the system

4) to demonstrate and monitor the integrated heating and ventilation system in a real home for a period of at least one year

5) to evaluate the data and to report on the results.

Furthermore, the main objective of the monitoring program is to determine whether the integrated heating and ventilation system design has resolved the five following issues :

1) supplying outdoor air to rooms.

2) tempering the outdoor air supplied to rooms;

3) integrating make-up air with exhaust fans;

4) managing air flows and associated pressure differentials;

5) meeting existing and future ventilation standards;

1.3 TECHNICAL APPROACH

This section summarizes the technical approach to the project.

The integrated heating, DHW and ventilation system comprises two subsystems (see Appendix-1):

1) the heating and DHW subsystem

2) the ventilation subsystem

An air management unit was designed as part of the ventilation subsystem. The air management unit modulates the supply of fresh air when exhaust fans are operated so as to maintain adequate ventilation to the house, maintain a balance of pressures and minimize make-up air demand.

The ventilation subsystem is designed to provide the base flow rate of ventilating air, thus managing both exhaust and intake flows, and to increase the air intake flow when required in order to compensate for occasional exhaust activities that would otherwise depressurize the dwelling.

This subsystem is not designed to provide for the combustion and dilution air needs of fuel-burning appliances, nor is it designed to compensate for the natural stack effect in the home.

The integrated system is under the control of a microprocessor device with a proprietary algorithm.

The design of the integrated system aims to insure that builders can meet the requirements of the 1985 National building code, including the revised versions of the code and the CSA F326 standard (in its draft form).

The integrated system, excluding the ventilation subsystem, is presently available to the residential market from les Industries DETTSON Inc., Sherbrooke (QC), and from its distributors (see Appendix-1).

1.4 CSA DRAFT STANDARD F326, "Residential Mechanical Ventilation Requirements"

In response to increasing concerns of combustion safety and inadequate ventilation in new houses, a draft standard, CSA F326 "Residential Mechanical Ventilation Requirements" has been developped to fulfill the need for a national set of residential ventilation requirements. Those requirements go well beyond what is required by the National Building Code. While not enforceable, it is proposed that this standard will remain in its preliminary form to give industries involved an opportunity to develop appropriate systems to meet these requirements before issuing the requirements as a formal standard.

This project is based on the May 1988 edition of draft standard F326.

As with the National Building Code Requirements, the standard does not make any specific reference to how the system be operated, or that it be operated at all. While the intent is to encourage the use of ventilation systems to ensure adequate indoor air quality, the primary goal is to ensure houses will have ventilation systems that adequately address issues of combustion safety and have the "capacity" to provide the requisite amount of fresh air to the house.

TABLE 1: MINIMUM VENTILATION AIR REQUIREMENTS (L/s)

Space Class	Base Supply Flow Rate L/s	Intermittent Exhaust L/s	Continuous Exhaust L/s
CATEGORY A			
Double/Mstr Bdrm	10		
Basement	10		
Single Bdrm	5		
Living Room	5		
Dining Room	5		
Family Room	5		
Recreation Room	5		
Other	5		
CATEGORY B			
Kitchen	5	50	30
Bathroom	5	25	15
Laundry	5		
Utility Room	5		

The flow requirements set out in the standard are derived from a number of sources including the R2000 program and ASHRAE. In general, it has been found that for most houses the ventilation rates equate to approximately 0,3 to 0,4 ACH. Again, while not trying to oversimplify the standard, a summary of its flow requirements are presented in table 1.

Recirculation systems must supply or exhaust a minimum of 20 L/s to each category A room and 5 L/s to each category B room with a minimum recirculation rate of 1 ACH. Fresh air delivered to the recirculation system must satisfy the Base Flow Rate for the dwelling calculated from Column 1.

In order to ensure safe operation of combustion appliances, specific depressurization limits have been established for combustion appliances. In addition, to minimize the potential detrimental effects of moisture exfiltration, positive pressure limits have also been established. These limits are based on extensive research and field documentation conducted by Canada Mortgage and Housing Corporation (CMHC) and other public and private organizations. These limits are outlined in the table 2. below.

TABLE 2: DWELLING UNIT PRESSURE DESIGN REQUIREMENTS

Limit	Category I	Category II	Category III
PIL	10 Pa	10 Pa	10 Pa
PDL	5 Pa	10 Pa	20 Pa

PIL: Pressure Increase Limit
PDL: Pressure decrease limit

Category I: Naturally aspirated fireplaces and furnaces
Category II: Induced draft furnaces
Category III: Condensing combustion appliances

PDL is based on the sum of...
- Net exhaust flowrate of ventilation system under Base flow rate condition

+

- Clothes dryer flowrate

+

- Next two largest exhaust appliances

In order to address issues of entry of radon and other soil gases, ventilation systems designed to operate continuously in a negative pressure mode must not exceed 10 Pa.

The standard also has requirements on tempering outdoor air and temperatures for delivered air to habitable spaces.

The requirements section of the standard is only one component of the standard. Two additional sections are also included. These are "Requirements for Installation" and "Requirements for Compliance".

To complete the standard, a design manual will be included. A preliminary version of this design manual has been developped and is available for review by industry.

2. TEST HOME DESCRIPTION

2.1 TEST HOME DESCRIPTION

The test home is a two-storey (2900sf) house of modern design built in the summer of 1987. Appendix-3 comprises eight views of the test home. The net inside volume of the house is 720 m3 and the area of the building envelope is approximately 562 m2.

2.2 AIRTIGHTNESS AND INFILTRATION

The airtightness and the air exchange rate of the test building were evaluated on the basis of four methods which aggree quite closely (see section 6.7).

Based on the fan depressurization test, the Air Change per Hour (ACH) at 50 Pa is about 2,90. The calculated ELA at 10 Pa is about 650 cm2 and the average ACH is about 0,15. Thus, the NLA is about 1,16 cm2/m2.

The airtightness of the test building is more representative of a typical home than of an ultra-tight or R-2000 home. The pressure-flow curve indicates that a net exhaust flow of less than 50 L/s is not likely to influence the depressurization of the house to a measurable degree.

2.3 HEATING SYSTEM AND ENERGY PERFORMANCE

The overall building heat loss in Watts per oC of temperature difference has been measured in the 87/88 winter during a relatively cold period with little wind and is approximately 161 W/oC. This includes only natural infiltration under these conditions and aggrees quite well with HOT2000 simulations.

The heating system comprises two zones, one for the ground floor and the other on the upper floor with supply outlets and return inlets for every Category A room and the laundry room. There is also a supply inlet and a timer-controlled exhaust fan in both bathrooms.

Until January 20th, 1989, the original system was a dual-unit (18 kW + 10 kW) forced-air all-electric system. The prototype of the DETTSON system was then installed along with the DACS for the purpose of the monitoring program.

Appendix-4 is the HOT2000 description and thermal simulation of the test home. Note that the measured natural infiltration data were included. The measured total electrical consumption for the year 1987/88 was about 26000 kWh, which aggrees rather well with the HOT2000 simulation. A HOT2000 simulation is also included for the DETTSON oil-based system under the same conditions. In this case, the base electrical consumption was increased to simulate the constant operation of both circulation fans.

2.4 HOUSEHOLD OCCUPANCY PATTERNS

During the 87/88 winter, the house was occupied by two adults and a newborn. One adult was away for the work hours of the weekdays.

During the 88/89 winter, the house was occupied by two adults and a one-year old child. All occupants were away for the work hours of the weekdays.

During the 89/90 winter, the house was occupied by two adults, a two-year old child and a newborn. One adult and one child were away for the work hours on most Mondays, Wednesdays and Fridays.

2.5 EXHAUST CAPACITY

Table 3. is the full list of the exhaust devices in the test home, with the manufacturer's rated air flow when available or applicable.

TABLE 3: EXHAUST DEVICES IN TEST HOME

		MANUFACTURER'S RATING
1. Bathroom fans (Nutone QT-110C)	(2)	52 L/s @ 25 Pa
2. Kitchen fan (Nutone WC-35)	(1)	307 L/s @ 50 Pa
3. System exhaust (vanEE 2000mvldh)	(1)	112 L/s @ 50 Pa (bal.)
4. Clothes dryer	(1)	40 L/s
5. Central Vac. (VacuFlow)	(1)	50 L/s
6. Fireplace	(1)	N/A
7. Oil burner (Beckett AFG-F6)	(1)	N/A

Further details and actual measurements are found in section 6.2.

Both the fireplace and the burner are fuel-burning appliances and thus not to be considered in reference exhaust flowrate calculations according to CSA draft Standard F326.

3. TECHNICAL ASPECTS OF SYSTEM DESIGN

3.1 DESIGN CRITERIA FOR THE INTEGRATED SYSTEM

The main design criteria for the integrated heating/ventilating system are as follows :

1. The system includes the following functions :

   - domestic hot water
   - space heating through forced air
   - air filtering
   - air humidifying
   - ventilation (exhaust and intake)
   - pressure control within the building
   - heat recovery as an option

2. Fuel type is oil or gas or dual-energy, with a single burner for both DHW and space heating.

3. The system must be integrated in the sense that all the elements are controlled from the same electronic control card through unified algorithms.

4. The system must make use of commercially available programmable thermostat controls.

5. The system must be modular such that an increase in capacity beyond a certain point can be obtained through zoning with identical fan-coil units. The capacity of the boiler unit is increased to a point by an increase in the capacity of the burner.

6. The system satisfies CSA draft Standard F326.1 requirements with respect to ventilation flows and pressure control.

7. The system relies on continuous circulator fan operation at low speed, while high fan speed is occasionally requested for thermal control or exhaust make-up.

8. Heating is achieved at low fan speeds inasmuch as possible.

9. The thermal control system must be able to temper the fresh air flow before it is delivered to the room.

10. Safety devices are included as required.

11. The system must be quieter than typical oil- or gas-fired forced air heating systems.

12. The manufacturing cost of the system should remain as close as possible to that of typical forced air heating systems including the addition of domestic hot water heating equipment. The comparison will be made with oil- based systems of similar capacity.

3.2 INTEGRATED SYSTEM DESCRIPTION

The integrated heating, DHW and ventilation system comprises two subsystems :

1) the heating and DHW subsystem

2) the ventilation subsystem

An air management unit has been designed as part of the ventilation subsystem of the integrated system. The air management unit modulates the supply of fresh air when exhaust fans are operated so as to maintain adequate ventilation to the house, maintain a balance of pressures in the house and minimize make-up air demand.

The integrated system is under the control of a microprocessor device with a proprietary algorithm. For the purpose of this CMHC project, control is achieved through the microcomputer (PC-AT) and the Sciemetric Data Acquisition and Control Unit (DACS) using a QUICKBASIC version of the control algorithm.

Figure 1. consists of a face schematic view of the dual-zone system as installed in the test home, with two supply ducting networks and a common return network.

The system in a typical home would most likely be single-zoned, with a corresponding simplification and capital cost economy.

3.2.1 HEATING, AND DOMESTIC HOT WATER SUBSYSTEMS

The heating and DHW system comprises two units and a control module :

1) the primary unit heats water. It is an oil-fired boiler with a double tank. The heating tank contains water for heating purposes. The DHW tank is contained within the first and thus indirectly heated. Domestic hot water is obtained from the DHW tank as for any water heater. Thus, the same burner serves both purposes with an increased efficiency. The burner is a BECKETT AFG with a built-in microprocessor control and a centrifugal inlet air shut-off that reduces cooling of the boiler when the burner is not operating.

2) the secondary unit heats air. It is a fan-coil subsystem that includes a dual-speed fan, a water heating coil, a variable-flow circulation pump, an air filter unit and a humidifier unit. The fan-coil subsystem is capable of raising the temperature of outdoor fresh air to above room temperature (e.g. 25oC) before introducing the air to occupied spaces. The fan normally operates continuously at low speed to provide the dwelling with constant air circulation, filtration and humidification.

3) the control module comprises a microprocessor device with a proprietary algorithm that manages the safety and control functions of the system such as :

   a) burner operation in order to keep an adequate boiler temperature;

   b) fan speed selection

   c) home pressure control

   d) circulator pump modulation in order to maintain the set room temperature by delivering a variable amount of heat power according to both thermostat demand and the indications of an additional temperature sensor located near the thermostat

   e) control of supply air temperature

Figure 2. is a piping diagram of the system.

Appendix-1 includes some of the technical documentation available on this product.

Appendix-2 is the Installation, Maintenance and Operation Manual for the present commercial version of the integrated system.

3.2.2 VENTILATION SUBSYSTEM

The ventilation subsystem is incorporated to the return duct of the secondary heating unit and comprises the following elements (see Figures 1., and 3(a,b,c)):

1) a mixing-box located in the return circuit of the heating system, as near as possible to the secondary unit (see section 3.3). The function of this device is to control the pressure in the dwelling within the 'Pressure Decrease Limit-Reference Exhaust Flowrate Condition' (CSA-F326.1).

2) exhaust ducting originating at the return circuit of the heating system, upstream of the mixing-box.

3) fresh air intake ducting (8 inches in diameter) connected to the make-up air inlet of the mixing -box and to the ventilation air inlet.

4) one exhaust fan unit with adjustable flow and set to the base ventilation flowrate for the dwelling (CSA-F326.1).

5) (OPTIONAL) one intake fan unit with adjustable flow and set to the base ventilation flowrate for the dwelling (CSA-F326.1).

6) (OPTIONAL) a heat recovery unit that combines items (4) and (5) (see Figure 3(c)). An HRV was installed in the test home for the 89/90 winter.

7) a pressure sensor (section 3.5) or a device capable of monitoring the operating status of selected exhaust equipment in the home, depending on the control strategy selected.

The installation of item (5) is recommended to provide a balanced flow in all cases where the required base ventilation flowrate exceeds the flow obtainable through return suction alone.

A control algorithm modulates the motorized air intake damper in order to compensate for exhaust devices in operation (see section 3.3).

3.3 DESIGN OF MIXING BOX

The mixing-box (see Figures 3(a,b,c)) is an insulated sheet metal duct section 20x20x20 inches that is inserted in the return air duct. There are two lateral openings.

The upstream opening is designed to inject the continuous base ventilation flow into the return flow. It therefore connects to the fresh air outlet of the intake fan or to the HRV (see Figures 3(a,b,c)). In the case of some smaller houses, it is possible that neither the intake fan nor the HRV be needed since the return duct suction may be sufficient to ensure the proper fresh air flow.

The downstream opening is closed by a spring loaded vane. This opening is connected to the fresh air intake ducting and is used to bring make-up air in the system. The mixing-box also comprises a rotating damper actuated by a stepper-motor under DACS or electronic card control. The damper is linked to the vane obstructing the fresh air intake.

For example, when a critical negative pressure is experienced, as signaled from the differential pressure sensor, a control algorithm modulates the motorized air intake damper and the exhaust fan motor or HRV. As the damper rotates, it simultaneously obstructs the return duct and opens the fresh air intake. The fresh make-up air flows in as a result of the return air plenum succion which can be augmented by increasing the circulation fan speed.

If the damper is completely closed and if the seal is good, the entire supply air flow is fresh air. However, because of the ducting arrangements, the total supply flow is then considerably reduced.

These different scenarios are shown in Figures 5(a,b,c).

It is important to recognize that the ventilation subsystem comprises a base flow device (in this case, a HRV) with an air flow calculated according to CSA draft Standard F326, while an additional outside air intake is modulated and follows the net home exhaust in order to comply with depressurization limits from CSA draft Standard F326. The base flow device is active most of the time, although there are some circumstances where it may be disconnected if the system recognizes that the other active exhaust devices in the home provide an adequate flow.

It must also be remembered that the integrated system operates continuously at low fan speed, and that the high fan speed is activated exceptionally for fast heating or to respond to temporary house depressurization.

The mixing-box approach allows the ventilation and compensation air flows to be brought into the home without the installation of an additionnal fan or ducting system to handle this load.

As installed in the test home, the mixing-box can inject up to 110 L/s of make-up air into the return duct without any external fan assistance other than the suction created by the circulation fan. This flow can be increased with slight design modifications that improve the seal of the mixing-box in closed position.

3.4 PRESSURE CONTROL ALGORITHMS

The control algorithm controls the dwelling temperature and the production of domestic hot water (DHW). Microprocessor control allows the precise metering of the heat power to the home as a function of the evolution of the control temperature in time.

The control algorithm also activates the ventilation subsystem in order to compensate for exhaust devices in operation.

Two approaches have been tested in the test site by modulating the damper through the DACS computer as a function of measured control variables. Eventually, the most successful approach may be incorporated to the system control board.

The two approaches share a common point. In both cases, pressure control is achieved by increasing the system fresh air intake by modulating the mixing-box damper (section 3.3) and by increasing the circulating fan speed (thus the return succion).

The two approaches differ as follows :

a) the first approach uses the pressure differential accross the enveloppe as the control variable. It consists of a classic feedback control loop.

b) the second approach is to continuously monitor the operating status of selected exhaust equipment (kitchen exhaust, dryer, etc.). Each thus provides a binary signal (ON/OFF), the weighted combination of which provides an estimate of the total mechanical exhaust air flow. The control system then determines the proper combination of damper motion and fan speed that will result in the required fresh air intake. This is a open-loop control arrangement.

The pressure differential approach has been shown to work in a favorable setting such as the test home and for relatively warm outdoors temperature. It requires an adequate and reasonably priced pressure sensor : such a device was developped by DETTSON (see section 3.5). The main problem with this approach is fundamental in nature and relates to the specific physical characteristics of each home that may result in cold weather stack effect pressure differences complicating the interpretation of the pressure sensor's readings. Further research and testing are required to make this approach reliable in actual field conditions.

The equipment status approach has also been tested and works reliably (see section 6.3). This approach, in the author's opinion, is rather crude and presents some disadvantages during installation and wiring. At the present state of research, however, it could be the most successful in actual field conditions.

Further discussions are included in section 7.2 of this report.

3.5 DESIGN OF PRESSURE SENSOR

A complete description of the DETTSON pressure sensor is retained until the patenting process is complete.

Functionally, the DETTSON pressure sensor is an electromechanical device with a pressure range from -7,5 Pa to +7,5 PA and provides a DC voltage output.

The signal from the pressure sensor is fed to and interpreted by the DACS and is part of the control algorithm.

The pressure sensor provides an averaged and stepped estimation of the pressure difference between the ports on each side of its casing. Tubing may be connected to either port to locate the air inlets such that wind velocity pressure will be minimized.

For example, as shown in Appendix 3(h), the pressure sensor is located in the basement with one port open to the room. The other port is connected to a tube leading into the attic which is used as a relatively isotropic settling chamber that helps to reduce wind-induced pressure fluctuations. Nevertheless, the pressure sensor still measures an indoors/outdoors pressure difference at basement level.

Section 6.3.1 aims at establishing the validity of the attic as a pressure reference input port location.

3.6 HEAT RECOVERY OPTION

An HRV was installed in the test home as shown in Figure 3(c) in autumn 1989. This is an optional heat exchanger apparatus inserted between the fresh air and exhaust orifice and the mixing-box. In many cases, an indirect connection of the ventilation supply air duct to the furnace return air duct is required in order to prevent an imbalance between the exhaust and ventilation flows in the HRV when the circulation fans operate at high speed; refer to the manufacturer's manual.

Although the HRV facilitates the tempering of fresh air, it is not a technical necessity and the decision is essentially an economic one: in the case of the test house, a simple air exchanger device consisting of two fans would have been entirely appropriate (see section 7.2.1).

The HRV installed in the test home is a vanEE 2000MVLDH.

3.7 FILTRATION AND HUMIDIFICATION OF AIR

The constant circulation of air at low fan speed is advantageous for filtration and humidification of air. Otherwise, the house ambient air is filtered and humidified only when the thermostat calls for heat. Thus, a markedly decreased rate of filtration is expected in fall and spring as heat demand is lowest, particularly in houses which, by design or accident, incorporate a significant amount of passive solar heating.

Given that the owner expects a relative humidity level of 30%-40%, the intake of large amounts of cold dry air in compliance with CSA draft Standard F326 creates a net humidity deficit and makes the humidifier a necessity. We have maintained very constant and adequate humidity levels in the test home.

The design of a pressure compensating (make-up air) system creates, however, additionnal constraints on the humidifying system. The most usual design consists of bypassing some warm air from the supply outlet of the furnace, feeding it through a drum evaporator and then into the return inlet of the furnace. In this system, however, the occasional mixing of warm moist air from the humidifier with outdoors cold air from the compensating system may result in unwanted condensation in the filters or upstream from the secondary heating unit coil. It was decided to recommend the use of an in-line humidifier consisting of a drum evaporator installed below an horizontal section of the supply outlet duct from the secondary heating unit in order to avoid the risk of condensation (see also section 7.2.2).

3.8 COMMISSIONNING OF SYSTEM

Once completely installed, the system is commissioned as follows :

* adjust the system circulating flow at low fan speed (via the proper choice of pulleys) in order to satisfy the following, most of which normally pertains to standard practice :

+ adequate ventilating air flow to each supply outlet

+ noise constraints

+ overall circulation rate in excess of 1,5 ACH

* adjust the HRV or intake/exhaust fans in order to obtain an exchange air flow equal to the base flow requirement as stipulated by CSA draft Standard F326 (or to the owner's judgement).

4. COMPLIANCE OF SYSTEM WITH PRELIMINARY STANDARD F326.

This section verifies in some detail the compliance of the designed system with CSA draft Standard F326. In some cases, compromises had to be made because of limitations to the equipment; in other cases, the equipment was designed in such a way that some F326 requirements became irrelevant.

4.1 VENTILATION AIR REQUIREMENTS

4.1.1 BASE FLOW RATE FOR DWELLING UNIT (F326-5.1)

The base flowrate for the test home is approximately 55 L/s as stipulated by CSA F326, and evaluated as follows :

TABLE 4: EVALUATION OF BASE FLOWRATE

CATEGORY A ROOMS		SUBTOTALS
Master bedrooms	1 @ 10 L/s	10
Single bedrooms	2 @ 5 L/s	10
Basement	1 @ 10 L/s	10
Living room	1 @ 5 L/s	5
Dining room	1 @ 5 L/s	5
		====
		40 L/s
CATEGORY B ROOMS		
Kitchen	1 @ 5 L/s	5
Bathrooms	2 @ 5 L/s	10
Laundry	1 @ 5 L/s	5
		====
		20 L/s
	TOTAL FOR HOME:	60 L/s

Since the total house volume is 720 m3, the prescribed air change rate of 0,30 ACH represents 60 L/s.

Because of noise and vibration constraints on the HRV equipment, 55 L/s were originally taken as the base flow rate over and above the estimated natural infiltration.

In march 1990, the base flow rate was set at 30 L/s, for an overall ACH of about 0,30 (including estimated natural infiltration).

4.1.2 INTERMITTENT AND REDUCED-FLOW OPERATION (F326-5.1.1, 5.1.2)

In the test system, the base ventilation flowrate is provided by a HRV unit.

CSA draft standard F326 requires that, in the case of intermittent operation, the average flowrate in any 24 h period is not less than the base flowrate and, in the case of reduced-flow operation, that the base flowrate be based on the minimum average flowrate in any 24 h period.

The defrosting control of the HRV unit installed in the test home interrupts the fresh air supply for 5 minutes every 45 minutes when the outside temperature drops below -5oC. The supply fan then pulls warm air from the room into the core while the exhaust fan stops for 2 minutes. Thus, the average ventilation air flow is about (48/(45+5)) = 96% of the set flow rate, and the HRV becomes an exhaust only device with unbalanced flow for 2 minutes.

According to tests by EMR on this model, the air flow reduction at low temperature (-25oC) is about 25% on supply and 19% on exhaust.

Thus, strictly speaking, a base flowrate of 55 L/s does not satisfy sections 5.1.1 and 5.1.2.

However, at a temperature of -25oC, infiltration and stack effect in most homes are expected to increase and to compensate partly for the reduction in HRV air flow.

4.1.3 CATEGORY A ROOMS (F326-5.2.1)

All category A rooms are equipped with supply and return grilles and thus satisfy section 5.2.1.

4.1.4 RECIRCULATION SYSTEMS (F326-5.2.3)

This criteria is satisfied since the total continuous circulation flow (at low fan speed) is in excess of 400 L/s with a house volume of 720 m3. Thus, the circulation rate exceeds 2.0 ACH on a continuous basis.

Simple arithmetics indicate that the total air continuously supply or removed in any room is in excess of 20 L/s.

4.1.5 EXHAUST FROM KITCHENS AND BATHROOMS (F326-5.3)

If intermittent exhausts are chosen for kitchen or bathrooms, draft standard F326 requires a minimum of 50 L/s for the kitchen and 25 L/s for the bathrooms. These exhausts should be non-recirculating.

In the test home, each bathroom has an independant exhaust fan with a capacity of about 20 L/s controlled with a timer switch.

There is a rangehood in the kitchen with a measured exhaust capacity of 98 L/s.

No heat recovery device is attached to these devices.

See measured results from section 6.2.

4.1.6 ROOM AIR DISTRIBUTION (F326-5.4)

The air distribution system in the test home comprises supply outlets and return inlets on opposite sides, in each room. Thus, the ventilation air is circulated quite equitably throughout the occupied zone.

Although individual supply air flow rates in each room were not measured in this project, SF6 air change measurements were made in individual rooms and showed that the ACH was consistent throughout the home. See section 6.7.4.

Note that distribution requirements are not met while the HRV is in defrost mode (5 minutes out of every 50).

4.1.7 SUPPLY AIR TEMPERATURE - THERMAL COMFORT (F326-5.5)

The fresh air is mixed in varying proportions with return air and then goes over hot-water coils for tempering.

The system is designed so that the continuously monitored supply air temperature does not fall to less than 2.5oC below the temperature at the thermostat (see section 6.4.3).

The system is also designed so that the supply air temperature does not exceed 60 oC.

4.1.8 MINIMUM AIR TEMPERATURE IN FURNACE (F326-5.6)

This requirement does not apply to the tested system which has been designed to accomodate air temperatures lower than 12oC in certain parts of the system..

The base flow of outside fresh air goes through the HRV if there is one and may be warmed-up. Otherwise, it flows directly over hot-water coils. Make-up air, however, always flows directly over the coils. No furnace heat exchanger is involved directly and the hot-water coils are designed to endure large temperature fluctuations.

Condensation on the coils is not an issue since we have relatively dry cold air flowing over warmer coils and since, moreover, coils are not likely to be damaged by condensation. Furthermore, the humidifying system was designed to minimize such condensation (see section 3.7).

Ducting upstream from the fan-coil unit as well as the fan-coil unit itself are insulated to prevent condensation one their exterior surfaces. Supply air downstream from the fan-coil unit is sufficiently warmed-up to prevent condensation.

4.1.9 MINIMUM SURFACE TEMPERATURE OF DUCTS (F326-5.7)

In the test home, when required, the distribution ducts are insulated so that the exterior duct surface temperature is never less than 14 oC.

Thus, the fresh air intake upstream from the HRV, the return plenum section were the fresh air is introduced and the HRV exhaust duct are adequately insulated.

4.2 DWELLING UNIT PRESSURE DESIGN REQUIREMENTS

4.2.1 PRESSURE INCREASE (F326-6.1)

The enveloppe surface of the test home is approximately 560 m2. Thus, the base air intake flow may not exceed the exhaust flow by more than (560 m2 x 0,012 L/sm2=) 67 L/s according to F326 (May 1988 draft) or, more recently, (560 m2 x 0,07 L/sm2=) 39 L/s according to HRAI Design and Installation Manual (January 1990).

This requirement is met since the HRV that provides the base ventilation flow is balanced.

4.2.2 PRESSURE DECREASE - BASE FLOWRATE CONDITION (F326-6.2)

The pressure decrease limit is set to 5 Pa since the dwelling incorporates Category I combustion appliances such as an oil burner with a naturally aspirated flue and a fireplace. Both devices obtain their combustion and dilution air from the dwelling.

The allowable Net Exhaust Flowrate at Base Flowrate condition is (560 m2 x 0,04 L/sm2=) 22 L/s according to HRAI Design and Installation Manual (January 1990). This also represents the Allowable Net Exhaust at the Reference Exhaust Flowrate Condition according to HRAI.

This limit is not exceeded during base flowrate conditions as a result of system operation since the system is balanced, BUT the pressure difference between indoors and outdoors at basement level may very well exceed minus 5 Pa for long periods of time as a result of normal house stack pressure effect for a two-storey house. Although this system is not required to control such pressure differences that do not result from the operation of exhaust equipment, they nevertheless are measured by the sensor and trigger undesired system responses. See section 7.2.

4.2.3 PRESSURE DECREASE - REFERENCE EXHAUST FLOWRATE CONDITION (F326-6.3)

According to CSA draft Standard F326 and HRAI, the Net Air Flow Rate at Reference Exhaust Condition for the test home is based on the sum of the kitchen fan, dryer and central vacuum net outflows. Based on manufacturer's specifications, this totals 397 L/s which exceeds the allowable by (397 - 22=) 375 L/s.

Based on actual flow measurements of exhaust devices flows, the Net Air Flowrate in fact totals 175 L/s.

Furthermore, the allowable Net Exhaust Flowrate may be assessed by an airtightness test in lieu of assumptions. In this case (see section 6.7), it was found that a critical flow of about 95 L/s created a depressurization of 5 Pa. Thus, the excess over the allowable is in fact (175 - 95=) 80 L/s.

Any combination of active exhaust devices for which the total flow exceeds 95 L/s will normally cause a depressurization in excess of 5 Pa. The following table lists the minimal combinations that closely approach or exceed 95 L/s in the test home. Any exhaust device activated in addition to any of these combinations will increase the depressurization in excess of 5 Pa.

TABLE 5: MINIMAL CRITICAL EXHAUST COMBINATIONS

1. Upper bathroom fan	:			o		o
2. Kitchen fan	:	o				
3. Fireplace	:		o			
4. System burner	:				o	o
5. Central vacuum	:			o	o	
6. Clothes dryer	:			o		o

4.2.4 CATEGORY I FUEL-BURNING APPLIANCES (F326-6.3.1)

The installed ventilation subsystem can provide make-up outside air up to 110 L/s (including HRV contribution) and thus falls short of the CSA F326.1 definition of the reference exhaust flowrate when based on assumptions.

However, based on actual exhaust flows measurements, the excess of the Net Exhaust Flow over the make-up air is (175 - 110=) 64 L/s which is less than the measured allowable value of 95 L/s.

Thus, in this test house as well as in a great number of homes, the make-up air capacity would be sufficient to reduce the depressurisation below the 5 Pa limit. Furthermore, slight design modifications to the mixing box, such as better sealing of the return damper, have been tested and do provide higher make-up flows.

5. DATA COLLECTION

5.1 LIST OF MEASUREMENTS

Appendix-7 is the master list for the monitored variables and includes the names of the monitored variables, when applicable, the sensor type, the input type (analog, digital or counter), and the location of the sensor. The names of the monitored variables usually correspond to the spreadsheet identifiers used when the data is saved to disk and are shown on the test home views of Appendix-3.

Appendix-7 also lists the spot measurements to be taken.

During the 88/89 winter, the continuous measurements indicated in Appendix-7 were made at 1 or 2 minutes interval, and 10 minutes averages were recorded.

During the 89/90 winter, when the DACS assumed full control of the system, DACS hardware limitations were such that the number of continuous analog measurements had to be reduced in order to improve the control cycling time. Thus, the list of measured variables became a subset of Appendix-7 such that device variables with predictable and stable values were evaluated by spot measurements and status monitoring.

For example, during the 88/89 winter, both flow and status were monitored for the kitchen fan; during the 89/90 winter, the kitchen fan flow is assumed to be either 0 L/s or 98 L/s, and only its status is monitored.

During the 89/90 winter, all continuous measurements were made and recorded at 2 minutes interval to allow effective analysis of the control sequences.

It was also found that a shorter logging interval was occasionally required for variables such as indoord-outdoors pressure differentials in order to assess the efficiency of the control system: a strip-chart recorder was then used for some experiments.

5.2 MONITORING EQUIPEMENT

The monitoring equipment comprises the following :

- one IBM PC-AT with two 5.25 floppy disks and one 70 meg hard disk as the supervisor for the Data Acquisition and Control System (DACS);

-one Sciemetric LABMATE 7000 DACS;

-one Sciemetric model 161 DAS;

-one AIR-NEOTRONICS micromanometer (with one SCANIVALVE used in the 88/89 winter);

-numerous sensors and accessories;

-one CANLAB dual-pen strip-chart recorder;

-two LPTB Low Pressure Transducers (Environmental Control Technology Inc.);

-the NOVA DACS software by Sciemetric in source form to allow SIRICON to introduce its own control procedures (88/89 winter);

-a SIRICON/DETTSON DACS software making use of modified Sciemetric LEVEL 1 routines (88/90 winter);

-the EXCEL spreadsheet system by MICROSOFT for the analysis of data.

The monitoring system allows a total of up to 32 analog inputs, 16 digital inputs and 5 counter inputs. The SCANIVALVE has 24 pressure channels (10 are used) and uses only one analog input, one digital output and one relay output on the LABMATE 7000. The LABMATE 7000 comprises 8 digital outputs, 2 relay outputs and 8 analog outputs for control purposes. A number of solid-state switching devices were built in order to activate power equipment with digital outputs.

6. DATA ANALYSIS

The data analysis following the monitoring of the test house is done in accordance with the objectives of the project and within its inherent time and budget limitations. Therefore, it is not always ideally sophisticated or complete and has no pretense in covering all the aspects of the subject.

6.1 SYSTEM AIR FLOW DATA

Figure 5. shows the main air flow parameters related to the integrated heating system in all its operation modes. Air flows were measured with vanEE four-point flow measurement stations and a micromanometer in January 1990.

These flow measurements were taken with filters clean. Flows may decrease markedly in time as a result of filters clogging-up if proper maintenance is neglected.

In the normal mode, the fans usually operate at low speed and the total circulated air flow is about 434 L/s or 2,2 ACH. It then contains about 13% of fresh air, all of it introduced through the HRV.

At the other extreme, the make-up mode with the make-up damper fully opened and the fans at high speed, the total circulated air is about 449 L/s or 2,2 ACH and the make-up air is about 110 L/s. It then contains about 38% of total fresh air introduced through both the HRV and the mixing-box damper. This last portion represents about 25% of the total circulated air and is not tempered by the HRV.

6.2 EXHAUST EQUIPMENT AIR FLOW DATA

The full list of the exhaust devices in the test home follows, with a measure or an estimation of the maximum exhaust flow under actual conditions.

TABLE 6: EXHAUST EQUIPMENT ACTUAL AIRFLOW DATA

1. Bathroom fans	(2)	20 L/s (estimated)
2. Kitchen fan	(1)	98 L/s (measured)
3. System exhaust	(1)	55 or 30 L/s (measured, balanced)
4. Clothes dryer	(1)	32 L/s (measured)
5. Central Vac.	(1)	43 L/s (measured
6. Fireplace	(1)	100 L/s (estimated minimum)
7. Oil burner	(1)	45 L/s (estimated)

The bathroom fan flows were estimated as about 40% of the manufacturer's rating of 52 L/s. When one bathroom fan is activated alone, the depressurization it causes is barely perceived on the instruments.

The manufacturer's rating for the kitchen exhaust fan is about 306 L/s at 50 Pa. Thus, the actual flow represents about 32% of the rating as a result of the ducting and the 'slot' inlet.

For most of the 88/89 winter, the system exhaust was 22 L/s, unbalanced. For the 89/90 winter, an HRV was installed to provide the base ventilation flow. For most of that heating season, the system exhaust was set to 55 L/s (balanced) as per CSA draft Standard F326.1 requirements. As of early March 1990, the system exhaust was then set to 30 L/s (balanced). This last setting thus relied on natural infiltration to attain a total ACH of about 0,3.

The clothes dryer flow measured is the maximum, without clothes in the dryer or lint on the filter.

The central vacuum flow is typical of its operation. It was measured with the usual accessories attached (25 feet of hose). Furthermore, the system is of the cyclonic type and has no filter that eventually becomes clogged.

The fireplace flow is estimated at about 100 L/s (minimum) on the basis of the literature and of depressurization measurements with the fireplace active during the 'chimney venting test'. When well established, the fireplace creates a depressurization that exceeds 5 Pa. From the house depressurization test, we know that 95 L/s is required to create a 5 Pa depressurization. Note that the flow from the fireplace can vary considerably with respect to the phase of the fire and to its steady-state intensity. See section 6.6.2.

The oil burner flow was estimated from the efficiency test. The stoichiometric air flow is 30 L/s at steady state upstream from the damper. Assuming a 50% dilution, the total chimney flow would then be about 45 L/s.

Both the fireplace and the burner are fuel-burning appliances and thus not to be considered in reference exhaust flowrate calculations according to CSA draft Standard F326.

6.3 DIFFERENTIAL PRESSURE DATA

In relation to the house pressure control by the integrated system, three aspects must be examined.

1) Is the attic a suitable location for an outside pressure tap, particularly with respect to wind pressure effects ? How does it compare to outside wall taps ?

2) How does the performance of the DETTSON pressure sensor compare with that of a micromanometer for the measurement of indoors/outdoors pressure differences ?

3) Assess the performance of the integrated system in controlling the house pressure.

The following sections address those questions.

6.3.1 PRESSURE REFERENCE POINT

We compare (DP1), the envelope pressure difference measured with a micromanometer and a single pressure tap located in the attic, and (DP2), the envelope pressure difference measured with the same micromanometer and four outside wall pressure taps. Wind and outdoors ambiant temperature are also recorded.

Figure 6. represents the evolution of the envelope pressure difference on a typical day with an average outdoors temperature of -7,1 oC.

The vertical scale is the house depressurization in (-)Pa or the wind speed in m/s depending on the curve read.

The upper curve (1) is wind speed in m/s (with square markers).

Curve (2) (DP2) is the envelope pressure difference in Pa between the basement and outdoors (at basement level), with the outside port connected to an averaging chamber with four outdoors wall taps about 15 feet from ground level, and measured with a micromanometer.

Curve (3) (DP1) is the envelope pressure difference in Pa between the basement and outdoors (at basement level) with the outside tap in the attic, and measured with a micromanometer.

Curve (4) (DPD) is the envelope pressure difference in Pa between the basement and outdoors (at basement level) as read by the DETTSON pressure sensor with its outside tap in the attic.

The following points are noteworthy:

1) All three pressure curves agree quite well when the wind dies down.

2) Curve (2) is very sensitive to wind, indicating that outdoors wall taps are not a reliable reference for control.

3) Curves (3) and (4) show a slight depressurisation of the attic as the wind increases, but the almost flat curve indicates that the attic is a valid reference location

4) Although all exhaust devices are turned off, the curves indicate an offset depressurisation of about 5 Pa which can be attributed to the stack effect.

By nature, these results are specific to the test home and cautious judgment is required when applying them to other types of houses or to other environments.

6.3.2 DIFFERENTIAL PRESSURE SENSOR PERFORMANCE

We compare (DP1), the envelope pressure difference measured with a micromanometer and a single pressure tap located in the attic, and (DPD), the same envelope pressure difference measured with the DETTSON pressure sensor.

Curves (3) and (4) of Figure 6. agree quite well, indicating that the accuracy and sensitivity of the DETTSON pressure sensor is adequate for control purposes.

6.3.2 PRESSURE CONTROL PERFORMANCE OF SYSTEM

Figures 7(a,b,c) are 8,5" by 14" sections of chart paper plotted during a pressure compensation (make-up air) test on March 4th, 1990 with an outside temperature of -12oC. The plotted variable is house depressurisation (in Pa) versus time. The different exhaust devices were activated in sequence or combined and are indicated on the chart (OB is the oil burner). The lengthwise scale is 1cm/min and the pressure scale is 1,5 Pa/cm. The left edge is 0 Pa.

The equipment status approach is used here in the control algorithm.

Note that a significant depressurisation is created when the kitchen fan is activated (about 5 Pa) and that this is brought under control within 30 seconds from the start. Similarly, when the fan is shut, the house is pressurised for about half a minute until the mixing-box damper reacts. These delays are mainly the result of limitations in the control program and could be reduced through an increased sampling rate in an eventual commercial version of the control unit. Note that when the kitchen fan is activated, the make-up air damper comes to its fully open position to allow the maximum possible amount of make-up air. See section 6.4.3 for an analysis of the supply air temperature control of the system.

The equipment status approach to the control algorithm appears to be effective. Note that the average background depressurization due to stack effect is about 6,9 Pa during this test. Thus, a direct pressure feedback approach to control the mixing-box would have required some form of dynamic compensation to offset the stack depressurization.

Figures 8(a...c) are a chart paper record of a similar test on April 6th, 1990 with an outside temperature of 2oC. In this test, a fire was prepared in the fireplace and some exhaust appliances were used. The average background depressurization due to stack effect is about 4,5 Pa during that test, Note the sharp peaks towards 0 Pa when exterior doors are opened/closed. There were gusts of wind up to 9 m/s during the test.

Similar tests were undertaken in Spring 1989 with a control algorithm using a classic feedback approach with the pressure difference measured by the DETTSON pressure sensor as the control variable. The outside ambiant temperature was relatively warm so that the stack effect was minimal.

The pressure control appeared good, with the mixing-box damper continuously moving back and forth within reasonable limits to follow residual pressure signal fluctuations. It was also verified that measured pressure fluctuations could be adequately damped by the electronic circuitry of the pressure sensor.

Unfortunately, these tests could not be monitored on a chart recorder, and the DACS could not be used with the high data logging rate applicable to these circumstances.

Considering the state of control algorithm development at that time, this approach could not, at that point, be applied to situations involving a large quasi-static background pressure difference such as that resulting from stack effects in cold weather.

6.4 TEMPERATURE AND SETPOINT DATA

6.4.1 TEMPERATURE SETPOINTS

There is a programmable thermostat (Honeywell CHRONOTHERM T8200) in each thermal zone. In both zones, the higher setpoint is 21oC (70oF) and the setback temperature is approximately 3oC lower.

In the main zone (main floor), the setback period is from 22:30 to 06:30. In the second floor zone, the setback periods are from 20:00 to 05:30 and from 07:30 to 18:30. Both programs run on a 7-days basis. These programs were essentially the same for the 88/89 and 89/90 winters.

It is noteworthy that the dial setpoint on each thermostat differs remarkably from the actual setpoint mentioned above and measured at the thermostat location : both thermostats have their dials set at about 18,5oC. The cycle rate control on both thermostats is set at the highest rate. Thus, in general, the thermostat dial setpoint cannot be relied upon.

6.4.2 AVERAGE ROOM TEMPERATURES

For the purpose of HOT2000 simulations and on the basis of figures such as Figures 10, we estimate the average setpoint temperature in the home at 20oC, the average actual temperature on the first and second floors at 18oC and the average actual temperature in the basement at 17oC. Averages are based on a full day of operation.

6.4.3 TEMPERATURE CONTROL PERFORMANCE OF SYSTEM

This section includes the time analysis of room temperatures for a typical day to illustrate the setpoint/setback programming and the temperature control performance of the system in this house.

Figures 9(a) and 9(b) represent the time evolution of temperatures and related operational variables in Zone #1 (Main living area) and Zone #2 (2nd floor-bedrooms) based on measurements for November 24th, 1990.

On Figure 9(a):

'TTint' is the control temperature read at the thermostat (continuous reading, averaged over 1 minute, logged every 2 minutes).

'Tliv' is the living-room temperature read every 2 minutes.

'FanHS' is the circulating-fan status (low- or high-speed).

'ThermosON' is the thermostat status for that zone (satisfied or demanding).

'CapacityFRAC' is the fraction of the available heating power that is currently used.

The heating schedule is described in section (6.4.1).

The following points are noteworthy:

1) the exceptional 'flatness' of the control variable in the steady-state;

2) the living-room temperature that is slightly lower than the control temperature, but that fluctuates within 0,7 oC at the most;

3) the slight overshoot of the living-room temperature in the morning as the thermostat setpoint is reset. The temperature rise in that mode is steeper and smoother with later versions of the control software (as in Zone #2);

4) fan speed is low at all times, except when the setpoint temperature is raised or, on other days, occasionally with very cold outdoors temperatures;

5) the modulation of capacity.

Figure 9(b) is similar to Figure 9(a), except for:

'TCH1' is the temperature in room #1 which is the master's bedroom, is larger but has two supply outlets.

'TCH2' is the temperature in room #2 which is smaller and has only one supply outlet.

The following points are noteworthy:

1) during daytime, the thermostat is on setback. Thus, this zone is heated to some degree by Zone #1;

2) There is a considerable amount of overshoot when the setpoint is raised in the morning. This is a characteristic of all central forced-air systems where the thermostat is in the corridor and where the heat is delivered at the periphery, in the rooms. This situation is worse when doors are closed. It is also much worse for other non-modulating forced-air systems.

Figure 10. relates to the exhaust depressurization test of Figures 7. described in section 6.3.2. It is an analysis of the temperature regulation capability of the integrated system when a large amount of make-up air is introduced through the mixing-box. The timespan of this figure corresponds to that of the chart paper of Figures 7. Data is logged every 2 minutes.

'TSUP1' is the supply air temperature in zone 1 with a thermostat in demand state.

'TSUP2' is the supply air temperature in zone 2 with a thermostat in satisfied state.

'TRETM' (lower curve) is the air temperature at the exit of the mixing-box, just before the fan-coil units.

The sharp drop in TRETM corresponds to the opening at 100% of the make-up air damper. TSUP1, in the demanding zone, fluctuates normally in accordance with the heating cycle. TSUP2, in a satisfied zone, remains at an acceptable level and is warmer than TRETM. Control in a commercial unit with a shorter control cycle would probably be smoother and more effective.

Figure 11. is also of interest since it shows the step drops in CO2 concentration associated with the two 100% openings of the make-up air damper during the depressurization tests of Figures 7. The CO2 concentration was measured in the return duct and thus represents the average for the house.

6.5 RELATIVE HUMIDITY DATA

6.5.1 RELATIVE HUMIDITY SETPOINT

In general, during the 88/89 and 89/90 winters, the humidity setpoint was 30%, except from november 1989 to the end of January 1990 were it was 40% for capacity testing purposes.

The humidistat was located besides the main floor thermostat.

As a result of the high ventilation flow stipulated by CSA draft Standard F326.1, the duct humidifier is definitely required to maintain these levels in the Montreal climate.

Occasional local humidity excesses resulting from activities such as bathing or cooking were readily controlled by local exhaust fans.

6.5.2 RELATIVE HUMIDITY MEASUREMENTS

Relative humidity was originally measured with capacitive RH sensors in the masterbedroom, the upper-bathroom and the main return plenum. In addition, a standalone dial-type RH meter was located besides the humidistat and spot measurements were taken occasionally with a sling psychrometer.

The capacitive RH sensors were soon found to be unreliable and erratic. The data thus obtained was not worth analysing.

Nevertheless, the dial-type RH meter and the spot measurements demonstrated that, except for some peaks resulting from local activities, the RH remained very close to its setpoint and was quite constant in all parts of the house.

The constant air circulation in the system certainly has a positive impact on RH regulation.

6.6 FAN AND OTHER EXHAUST DEVICES OPERATIONAL DATA

6.6.1 DEVICE OPERATIONAL STATISTICS

From January to March 1990, the fireplace was used three times, each for a duration of about 3 hours with doors opened. The doors were then closed and the fire left to die out. Typically, fireplace use in the test home is essentially for enjoyement rather than for heating purposes and it is usually not used simultaneously with mechanical exhaust devices.

Mechanical exhaust devices operational data was analysed for three 31-day periods from January 9, 1990 to April 11, 1990. The results are presented on four bar-charts for January, February, March and the 3-month average on Figures 12, 13, 14 and 15.

Each bar represents a combination of devices while the vertical scale is the time logged for each combination in minutes. Each bar also has its time duration indicated.

Each combination is identified by a combination of KI (kitchen range fan), DR (clothes dryer), VA (central vacuum cleaner), BA (upper bathroom fan) and BU (oil burner). The status of the lower bathroom fan was not monitored due to wiring difficulties, but this fan was seldom used.

These statistics are, of course, specific to this home and to the use pattern. This family, for example, makes extensive use of a microwave oven for cooking purposes. The use of the cooking range and the kitchen fan are therfore not as frequent as one could expect.

During the logging interval, 16 combinations were activated : 5 singles, 7 duals and 4 triples. Of these combinations, the critical ones with respect to burner operation are such that the mechanical exhaust flow (excluding burner flow) approaches or exceeds 95 L/s (see section 4.2.3) and the oil burner operates. These are combinations KIBU, KIBABU and KIDRBU which total 32 minutes in January, 28 minutes in February, 12 minutes in March and 24 minutes/month on average. These times represent actual and potentially dangerous conflicts between the oil burner and the mechanical exhaust devices.

Coincidence data is not available for the fireplace, and we cannot give actual conflict times. However, the potential conflict times can be estimated. Critical combinations with respect to the fireplace are any combination such that the exhaust flow exceeds 95 L/s. These are KI, KIBU, KIBA, KIBABU, KIDRBU, DRVABU and DRBABU which total 220 minutes in January, 108 minutes in February, 108 minutes in March and 146 minutes /month on average. These times represent potential conflicts if the fireplace had been operating.

6.6.2 DEVICE-INDUCED DEPRESSURIZATION

In some cases, device-induced depressurization could be measured in the test home. The values obtained are usually quite approximate due to normal and omnipresent pressure fluctuations. See Figures 7 and 8.

In the case of the fireplace, the pressure difference between an open-door fire and a tightly closed door fire was measured.

TABLE 7: MEASURED DEVICE-INDUCED DEPRESSURIZATION

DEVICE	APPROX. DEPRESSUR.
1. Bathroom fans	0 Pa
2. Kitchen fan	5-6 Pa
3. System exhaust	0 Pa
4. Clothes dryer	2 Pa
5. Central vac.	3 Pa
6. Fireplace	5 Pa
7. Oil burner	3 Pa

6.7 AIRTIGHTNESS AND AIR INFILTRATION DATA

6.7.1 DEPRESSURIZATION TESTS

Airtightness of the test home was measured by the fan depressurization method according to CGSB-149.10 and used a blower door with an axial fan, bell-mouthed nozzle and manometers for measuring the flow rate of air leaving the building and the envelope pressure differential. No specific sealing measures were taken although the damper and doors on the fireplace were kept closed as this is normally the case.

Given an indoor temperature of 19oC and an outdoor temperature of 5oC on December 12th, 1988, the results were as follows :

ELA at 10 Pa : 668 cm2
ACH at 50 Pa : 2.90
C factor : 27.573
n exponent : 0.770

These values correspond to an average infiltration rate of about 0.15 ACH. Figure 16. is the flow/pressure diagram for that test.

6.7.2 AVERAGE AIR EXCHANGE RATE

Average air exchange rate or air change per hour (ACH) measurements were made with the BNL-AIMS (Brookhaven National Laboratory - Air Infiltration Measurement System). The BNL-AIMS employs a passive miniature perfluorocarbon tracer (PFT) source and a passive sampler (CATS - capillary adsorption tube sampler) to determine a time averaged indoor tracer concentration. The reciprocal of this concentration times the source rate is approximately equal to the average infiltration rate. Sampling periods periods can be as short as 2 hours and as long as several months.

According to its promoters, comparisons of this technique with simultaneous measurements by SF6 decay, SF6 steady-state, automated SF6 decay and blower door techniques have shown the BNL-AIMS to be simpler, more reliable and more consistent from one measurement to the next.

One test was made on the dwelling, approximately seven (7) days in duration. The test was done with no mechanical ventilation in early February 1989. A source/sampler couple was located in the basement, and another one on the main floor.

The 1989 test indicate an overall infiltration rate of 144 m3/h (sd = 34 m3/h) and an overall air exchange rate of 0,21 ACH (sd = 0,05 ACH). The degree of uncertainty could have been reduced by increasing the number of samplers in each zone in the home.

6.7.3 INDIRECT AIR EXCHANGE MEASUREMENTS

On March 1st and March 2nd, 1989 during the course of CO2 monitoring (section 6.8.3), the air exchange through the envelope of the building could again be evaluated on the basis of CO2 dilution analysis. Figures 17(a) and (b) are the CO2 concentration as a function of time for those days. The CO2 decay curve that follows the departure of the occupants, when indoors sources are then negligible, can provide a reliable estimation of the average ACH during those hours. Results are 0.13 ACH on March 1st and 0.10 ACH on March 2nd. See section 6.8.3.

6.7.4 SF6 TRACER GAS TESTS

On March 21th and March 25th 1990, SF6 air exchange measurements were made at 5 locations in the test house. Following injection of the tracer gas, samples were taken at regular intervals in the return plenum, the basement, the living-room, the master-bedroom and another bedroom.

In both cases, the HRV was set at 30 L/s (balanced), outside temperature was about 0oC and the wind was less than 2,5 m/s.

For the first test, the average (whole house) ACH was 0,40 and the air change rate in each room deviated from the average by less than 0,04 ACH in all cases.

Similarly, for the second test, the average (whole house) ACH was 0,24 and the air change rate in each room deviated from the average by less than 0,01 ACH in all cases.

These results illustrate the large variations in the air exchange rate to be expected under very similar conditions, for no obvious reason. They also demonstrate the efficiency of fresh air distribution throughout the house since the ACH is quite constant from room to room.

6.8 OTHER TESTS

6.8.1 FORMALDEHYDE TESTS

The formaldehyde level was obtained with AIR QUALITY RESEARCH INC. detector tubes left in place seven (7) days each and then processed by ORTECH International.

For each test, one tube was installed in the Master Bedroom and the other in the Main Floor Living Area.

One test was done with no ventilation except for natural infiltration in February 1989, and the other with 55 L/s of balanced mechanical ventilation in January 1990. The results are expressed in parts of formaldehyde per million parts of air (ppm) as follows:

TABLE 8: FORMALDEHYDE TESTS RESULTS

LOCATION	VENT. FLOW = 0 L/s (test #1)	55 L/s (test #2)
Master Bedroom	0,035 ppm	0,019 ppm
Main Floor Living Area	0,038 ppm	0,018 ppm

Since the house was more than 1,5 year old at the time of the first test, it seems reasonable to attribute the decrease in formaldehyde level for the most part to the increased ventilation.

Health and Welfare Canada sets an indoor air quality guideline for formaldehyde at 0,10 ppm. Levels found at this residence were all well below this limit.

6.8.2 RADON TESTS

Radon tests were achieved with M-1 surveymeters from R.A.D. Service and Instruments Ltd., Scarborough, Ont. Each surveymeter consists of a constant air flow pump with a detecting head assembly. Following exposure, the detector assembly is processed by R.A.D.

All Radon evaluations were made by locating the surveymeter in the basement, for an approximate exposure duration of seven days.

Two tests were done with no ventilation except for natural infiltration in February and March 1989, one with 55 L/s of balanced mechanical ventilation in February 1990 and a last one with 30 L/s of balanced mechanical ventilation in March 1990. Apart from the increased ventilation, the only remedial action taken in 1990 with respect to Radon was to seal off the sump pump pit.

The results are expressed in 'working level unit' (WL).

TABLE 9: RADON TESTS RESULTS (in WL)

TEST	AIR FLOW = 0 L/s	30 L/s	55 L/s
#1 February 1989	0,016		
#2 February 1989	0,023		
#3 February 1990			0,005
#4 March 1990		0,012	

The 1989 Radon test results (without ventilation) indicate a concentration approximately equal to the 'action level' of 0,02 WL, according to the Departement of National Health and Welfare or the US EPA.

This relatively high concentration is about 4 times the average indoor level, and is suspected to be related to the granitic bedrock underlying the home about 3 feet from the basement slab. The test home is built near Mont Saint-Hilaire, which is a mountain of igneous origin.

The test in 1990 at 55 L/s, including the sealing remedial action shows a fourfold reduction in the radon level.

6.8.3 CO2 MONITORING

An ADC PM2 portable infrared gas analyser was connected to an air line from the return duct in order to monitor the average CO2 concentration (PPM) in the test home. The analyser was wired to a port on the DACS for continuous data logging. Each day of the monitoring period, every 24 hours, the analyser was recalibrated for the zero and the span settings using a CO2 scrubber media and a reference gas. The data shown here is corrected on the basis of an assumed linear calibration shift.

During the monitoring period, a log book was kept in order to record all events that may have influenced the CO2 concentration in the home.

In early March 1989, spot measurements of the outdoors CO2 concentration were made on six days : all measurements were very close to 360 PPM.

In early March 1989, the indoors CO2 concentration was continuously measured for one week with no ventilation except for natural infiltration.

Data obtained on March 1st and March 2nd is typical of weekdays patterns and is shown in Figures 18(a) and (b). On March 1rst, the average outdoors temperature was about -4oC and the average wind speed was about 6 m/s. Corresponding values for March 2nd were -10oC and 6 m/s respectively.

As expected, the CO2 concentration closely reflects the occupation and activity patterns of the house at that time with 2 working adults and 1 child, and appears to be a reliable ventilation demand control variable.

The air distribution duct system and constant circulation flow in the test system are such that the CO2 level can be reasonably well modelled with a one-compartment model. Thus, the return duct CO2 concentration is a reliable estimation of the average CO2 concentration in this 720 m3 home. In some circumstances of constant occupation (eg. week-ends) without mechanical ventilation, the CO2 level may exceed 1000 ppm. It is expected that the CO2 level in individual rooms would rise markedly above the average if the circulation flow was intermittent or inexistent as in most forced warm air heating systems or baseboard installations.

From about 08:00 to 18:00, the house was not occupied and the CO2 decay curve was used to evaluate the airtightness of the building.

Similar monitoring took place during February 1990 with an increased level of ventilation as per F326.1 and with a different occupation pattern. It appears on Figure 19. During that week, the CO2 level never exceeded 550 ppm.

6.8.4 CHIMNEY VENTING AND SPILLAGE TESTS

A chimney venting and spillage test was made on March 3rd, 1989. It made use of the Chimney Safety Tests User's Manual (2nd edition) and comprised the Venting System Pre-Test and then the Venting System Test.

6.8.4.1 Venting System Pre-Test

The TOTAL EXHAUST FLOW was estimated as 445 L/s based on Table 1.1 of the Manual, or 313 L/s based on actual measurements.

The UNINTENTIONAL LEAKAGE AREA can be estimated based on the tightness test (see section 6.7) ELA at 10 pa which is about 650 cm2. No INSTALLED ELA was considered. No HRV was installed at that time.

The MAXIMUM DEPRESSURIZATION LEVEL (MDL) was obtained from Table 1.3 of the Manual and is in excess of 17 Pa.

The house DEPRESSURIZATION LIMIT (HDL) for the oil burner is based on a metal-lined insulated chimney 8,2 meters in height attached to the exterior wall. According to Table 1.4, the HDL is 6 Pa. The HDL for the fireplace is based on a metal-lined insulated chimney 6,0 meters in height attached to the exterior wall. According to Table 1.4, the HDL is 4 Pa.

Since, in all cases, the MDL is greater than the HDL, chimney spillage is considered a potential problem and the house must be tested by means of a full Venting System Test.

6.8.4.2 Venting System Test

The Venting System Test for the fireplace (open-door mode) was carried out with an actual fire and the depressurization was measured with the micromanometer.

All exhaust appliances and the burner were first turned on. It was impossible to start the fire without opening a window. Once the fire became well established, the window was closed. The measured depressurization reached 14,5 Pa. The fireplace started spilling a curtain of smoke accross the top of the door. The spill ceased as soon as the exhaust fans were turned off.

Under similar circumstances, while the oil burner did not operate, the draft was reversed in the oil burner flue, with air spilling out of the dilution air inlet. When the burner was started, a normal draft was established and the spill ceased in less than 30 seconds.

6.9 ENERGY SUMMARY

For the duration of the CMHC monitoring program, energy monitoring was achieved on the basis of meter readings for electricity, oil and DHW. These readings were normally made on a weekly basis, although they were made on a daily basis for more than 2 months in the 89/90 winter.

In addition, electrical meter readings were made on a weekly basis from mid-summer 1987 to January 1989, before this CMHC project and while space and DHW heating were electric. Thus, further comparisons and correlations are possible.

6.9.1 TOTAL ELECTRICITY CONSUMPTION

Appendix 8. lists the meter readings for the total electricity consumption from July 1987 to the end of May 1990, as well as some derived quantities.

The meter is a standard Hydro-Québec device with a 40x factor.

The electrical consumption from January 20th, 1988 to January 20th, 1989, while all the energy used was electric, was about 26000 kWh. This was quite accurately modelled in a HOT2000 simulation included in Appendix 4.

As of January 20th, 1989, both DHW and space heating requirements were oil-based. However, the electricity consumption included the continuous operation of two circulating fans (about 29 kWh/day) and, in automn 1989, the operation of the HRV (about 3,3 kWh/day). The energy used to power the circulating fans actually contributes to space heating.

6.9.2 HEATING AND DHW OIL CONSUMPTION

Appendix 9. lists the oil flowmeter readings from January 20th, 1989 to the end of May 1989, as well as some derived quantities.

The energy equivalent is also given on the basis of 10,7 kWh/liter for standard no.2 heating oil.

6.9.3 DOMESTIC HOT WATER (DHW) CONSUMPTION

Appendix 10. lists DHW flowmeter readings from January 20th, 1989 to the end of May 1989, as well as some derived quantities.

This represents the hot water used at its average delivery temperature at the appliance (about 60oC) and was an average of 0,27 m3/day in the second half of Winter 1990.

In an attempt to determine the energy cost of DHW, the input cold water temperature was measured at irregular intervals and varies from about 4oC in winter to about 12oC in mid-summer. Based on assumed average cold water temperatures as shown in Appendix 10., we conclude that an average of about 17 kWh/day was spent on DHW heating in the second half of Winter 1990.

6.10 COST SUMMARY

We compare the Integrated Heating and Ventilation System (IHVS) with a similar conventional system comprising an oil-fired air furnace and a separate oil-fired DHW boiler.

We will consider a single-zone home.

It will be assumed that the operation of both systems will be as closely similar as possible and that partial compliance with CSA draft Standard F326 will be attempted with the conventional system.

Both systems run the circulator fans continuously. The conventional system requires a Heat Recuperating Ventilator (HRV) connected to its existing ductwork while the IHVS requires only an air exchange unit comprising two small fans and the associated exhaust and intake ducts.

6.10.1 CAPITAL COSTS

The comparison is based on 1991 costs to the consumer and excludes provincial taxes.

TABLE 10: CAPITAL COSTS SUMMARY

	INTEGRATED SYSTEM	CONVENTIONAL SYSTEM
A) SYSTEMS		
Hot air furnace	-	1500$
HMD boiler (*)	3102$	-
FC fan-coil unit (**)	1183$	-
Hot water boiler	-	1450$
Air exchanger	200$	
HRV unit	-	1500$
Mixing-box	180$	-
Pressure sensor	240$	-
	=====	=====
SUB-TOTAL:	4905$	4450$
B) INSTALLATION		
Addt'l plumbing	300$	-
	=====	=====
SUB-TOTAL:	300$	0$
FINAL-TOTAL:	5205$	4450$

NOTES: (*) includes: draft regulator, drain valve, burner cover, mixing valve, sound trap, relief valve and microprocessor control of the system;

(**) includes: 2-speed motor, circulator pump, expansion tank, paper filter, circulator flanges and gravity check valves.

6.10.2 MAINTENANCE COSTS

Maintenance costs are essentially the cost of a service contract. The only difference between both systems is that the conventional system has 2 oil burners.

We can reasonably assume that the integrated system would cost about 150$ in service contract, and that the conventional system would cost about 300$.

6.10.3 OPERATING COSTS

It is assumed that both systems are operated in a similar manner when applicable or possible.

There will be little difference between the operating (energy) costs of both systems, except for the following aspects that cannot be assessed at this point.

1) the integrated system might be slightly more efficient through the use of a single burner, combined heating/DHW functions and finer thermal control;

2) the integrated system will result in additional fresh air heating costs whenever make-up air is introduced for pressure control;

3) since it is assumed that the IHVS uses an air exchange unit instead of an HRV unit, the ventilation air would cost about 100$ more per year than for the conventional unit.

4) the reaction of owners of the IHVS to its finer thermal control that results in reduced temperature fluctuations in rooms may be to lower the thermostat setpoint, with associated space heating energy savings of about 8% for a 1oC reduction in the average setpoint.

6.11 OCCUPANT SURVEY

6.11.1 SUBJECTIVE THERMAL COMFORT

The occupants found a definite comfort improvement associated to the fine temperature control of the system such that room temperature fluctuations are markedly reduced.

The occupants find that the constant flow of supply air at room temperature is not particularly objectionable.

6.11.2 SUBJECTIVE ASPECTS OF IAQ

During the heating season, before ventilation air was introduced in the house, the occupants always noticed a certain stuffiness of the air, particularly in the morning in the bedrooms or following the preparation of meals.

This sensation disappeared as soon as the system introduced fresh air in the home as per CSA draft Standard F326. A ventilation rate reduced to 0,15 ACH to rely partly on natural air infiltration was still found to be adequate.

7. CONCLUSIONS

7.1 COMPARATIVE COSTS OF SYSTEMS

Section 6.10 compares the costs of the integrated system with those of a similarly equipped conventional oil-fired system. The integrated system (IHVS) monitored in this project has slightly greater capital costs (by 755$), but equivalent or lower maintenance and operating costs.

We consider that a conventional forced-air heating system can be set for continuous air circulation and that an HRV can be connected to it. Thus, the base ventilation flow requirements of CSA draft Standard F326 can, to some extent, be satisfied and the owner will also benefit from improved filtration and relative humidity regulation.

However, the IHVS alone is designed at the onset on the basis of CSA draft Standard F326. Its 755$ capital cost premium could be justifiable on the sole basis of an improved temperature control and increased level of safety in relation to pressure control, integration of burner operation and separation of the flue gaz stream from the circulation air stream by an intermediate heat transport loop.

7.2 SYSTEM PERFORMANCE - THERMAL CONTROL

7.2.1 HEAT RECOVERY OPTION

Three HOT2000 simulations are included in this report in Appendices 4., 5. and 6. for the purpose of evaluating the energy impact of ventilation without heat recovery and are based on the house model as in section 2.1 (Appendix-3).

Appendix-5 simulates the average natural infiltration of the test house and adds 0,15 ACH of mechanical ventilation, for a total of 0,30 ACH (scenario adopted in March 1990). The energy premium is then about 1600 kWh/year or about 80$ in electricity (Quebec, 1990).

Appendix-6 simulates the average natural infiltration of the test house and adds 0,30 ACH of mechanical ventilation as per CSA draft Standard F326.1, for a total of 0,45 ACH (winter 1989-1990 up to March 1990). The energy premium is then about 4600 kWh/year or about 220$ in electricity (Quebec, 1990).

Considering a seasonal efficiency of about 50% for the HRV, the annual savings would then be about 40$ and 110$ respectively. When taking into account the added maintenance burden as well as the reduced efficiency of a HRV under deficient maintenance conditions, it is relevant to question the profitability of such a unit under average conditions in practice. Its main advantage would in fact be only to temper the ventilation air, but this is not a requirement of the designed IHVS.

7.2.2 HUMIDIFYING EQUIPMENT

As stated in section 3.7, the IHVS includes an in-line humidifier consisting of a drum evaporator installed below an horizontal section of the supply outlet duct from the secondary heating unit.

It was found, however, that this solution may induce an increased risk of introducing potentially harmful micro-organisms in the home environment, particularly when the water supply contains a significant amount of organic matter. First, the warm moist air from the humidifier is not filtered since the humidification process takes place at the outlet of the heating unit while filters are at the inlet. Then, manufacturers of in-line humidifiers tend to use clear plastic water pans that protrude below the duct. Whenever light shine on the system, the production of algae is promoted. It is known that bacteria such as legionella seem to thrive in warm environments that contains organic matters such as algae.

Indeed, in the test home, after a two month period, the content of the humidifier pan was greenish with important quantities of green suspended filamentous matter.

Since the domestic water supply (hence the humidifier supply) was run through a cartridge suspended matter filter, it seems that primary water filtration is not an effective solution to this problem.

One solution would be to use a standard bypassing type of humidifyer with an electric interlock from the control module that would prevent rotation of the evaporator drum whenever cold make-up air is directly introduced in the system.

Another solution might be to maintain an adequate algae and bacteria growth inhibitor in the humidifier pan.

7.3 SYSTEM PERFORMANCE - PRESSURE CONTROL

The feedback approach with the envelope pressure difference as the control variable in the pressure control algorithm has been shown to work in a favorable setting such as the test home and for relatively warm outdoors temperature. It requires an adequate and reasonably priced pressure sensor : such a device was developped by DETTSON and was described in the section 3.5. The main problem with this approach is fundamental in nature and relates to the specific physical characteristics of each home in two main aspects:

a) Any pressure difference measurement between the inside of the building and the outside includes a natural stack effect component that varies with the envelope temperature difference. In the test home, the measured pressure difference at basement level largely exceeds 5 Pa in very cold weather. The natural stack component is quasi-static and, therefore, cannot be damped-out electronically.

The CSA draft Standard F326, on the other hand, seeks to control the depressurization induced by exhaust devices, and this excludes the natural stack effect. In other words, the depressurization limit is incremental and not absolute. Fortunately, the natural stack effect is most significant at low outdoors temperatures during which flue devices function at their best and cause the least concern.

In order to circumvent this problem, it could be possible to isolate the incremental equipment-caused depressurisation from the natural stack-caused background depressurisation by a suitable and relatively complex algorithm. This algorithm must take into account the combination of exhaust equipments that add up to the prescribed limit but that are activated at different times, while accomodating quasi-static variations in stack-induced depressurisation with time. For this purpose, the pressure sensor must provide a numerical or step-wise reading of the pressure differential and not a binary indication of whether the differential is above or below a given setpoint. The DETTSON pressure sensor comes close to fulfilling this requirement.

Otherwise, the stack effect can be compensated for and eliminated by locating the pressure sensor at the neutral plane or by mathematical correction. However, both remedies require an assumption regarding the location of the neutral plane which varies with time and is house-specific. In any case, this type of analysis relies heavily on the capabilities of the heating system installer.

b) Any pressure port on the outside is influenced by wind velocity pressure. Although, in the test home, the attic provides an adequate location for the pressure tap (see section 6.3), no two homes behave identically in this respect, and we must once again rely on the judgment of the heating system installer.

In the author's opinion, further research and testing are required to improve the reliability of this approach for buildings and climates where the envelope temperature difference results in a significant natural stack effect.

The equipment status approach has also been tested and works reliably (see section 6.3). However, it requires, at the present state of technology, a considerable amount of effort to wire status lines and relays to the selected exhaust devices, particularly in existing homes. This, however, can possibly be improved if a suitable solid-state status monitoring device can be designed. Furthermore, this method requires a relatively precise estimation of the actual flow capacity of the selected exhaust devices.

Considering the present state of research, nevertheless, the equipment status approach could be, in the author's opinion, the most successful in actual field conditions.

7.4 F326.1 RESIDENTIAL VENTILATION STD - BASE FLOW RATE

According to the commentary on CSA draft Standard F326, the base flow rate determined on the basis of F326, on a continuous basis, would satisfy 11 adults at rest or 7 sedentary adults based, respectively, on 5 L/person-second and 7,5 L/person-second of fresh air, and for an equilibrium CO_2 concentration of 1000 ppm.

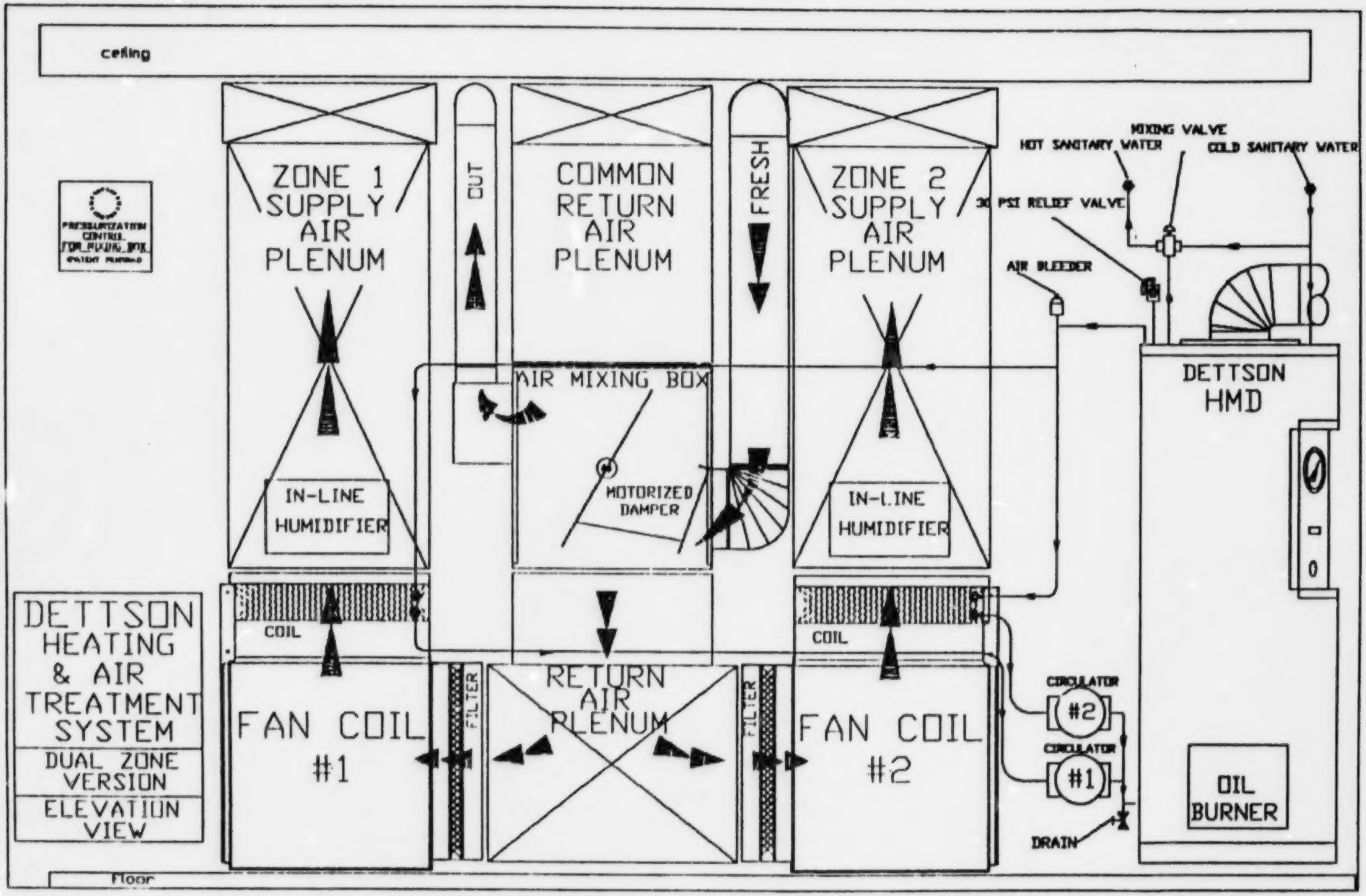
Furthermore, if an average natural infiltration flow is considered for the test home, the overall ACH becomes 0,45 and then satisfies 12 sedentary adults. Thus, a continuous fresh air flow of 55 L/s appears rather exagerated for a family of 2 adults and 2 children with no smokers particularly with predictable occupancy patterns including significant periods with no occupants.

In march 1990, the base flow rate in the test home was set at 30 L/s, for an overall ACH of about 0,30 (including estimated natural infiltration). The results were satisfactory.

For reasons of economy, both in capital costs and in operation, we recommend that CSA draft Standard F326 include a provision to account for natural infiltration in the calculation of the base ventilation flowrate, when possible.

We also feel that the subject of demand ventilation is worthy of consideration and further research. For example, a greatly reduced base ventilation flowrate could be acceptable in periods of low occupation or activity, and the flow could then increase according to a program or to occupation/pollutant sensing and possibly to flowrates above CSA draft Standard F326 airflow guidelines. Such optimisation could, possibly, reduce the overall energy costs while providing better indoor air quality than the continuous and constant ventilation flow specified in CSA draft Standard F326.

FIGURES



ceiling
PRESSURIZATION CONTROL FOR MIXING BOX
PATENT PENDING
ZONE 1 SUPPLY AIR PLENUM
OUT
COMMON RETURN AIR PLENUM
FRESH
ZONE 2 SUPPLY AIR PLENUM
MIXING VALVE
HOT SANITARY WATER
COLD SANITARY WATER
30 PSI RELIEF VALVE
AIR BLEEDER
AIR MIXING BOX
MOTORIZED DAMPER
IN-LINE HUMIDIFIER
IN-LINE HUMIDIFIER
DETTSON HMD
COIL
COIL
DETTSON HEATING & AIR TREATMENT SYSTEM
DUAL ZONE VERSION
ELEVATION VIEW
FAN COIL #1
FILTER
RETURN AIR PLENUM
FILTER
FAN COIL #2
CIRCULATOR
#2
CIRCULATOR
#1
DRAIN
OIL BURNER
floor

FIGURE 1.
Face schematic view of integrated system

1. AQUEDUC
2. BOILER SUPPLY
3. CHECK-VALVE (3/4")
4. EXPANSION TANK
5. FAN-COIL UNIT
6. AIR VENT
7. CIRCULATOR
8. 12 PSI PR. RED. VALVE
9. DRAIN VALVE
10. BOILER RETURN
11. SAFETY VALVE (3/4")
12. DOMESTIC COLD WATER INLET
13. DOMESTIC HOT WATER OUTLET
14. MIXING VALVE (1/2")
15. DOMESTIC HOT WATER MIX.
16. HMD OR HM BOILER

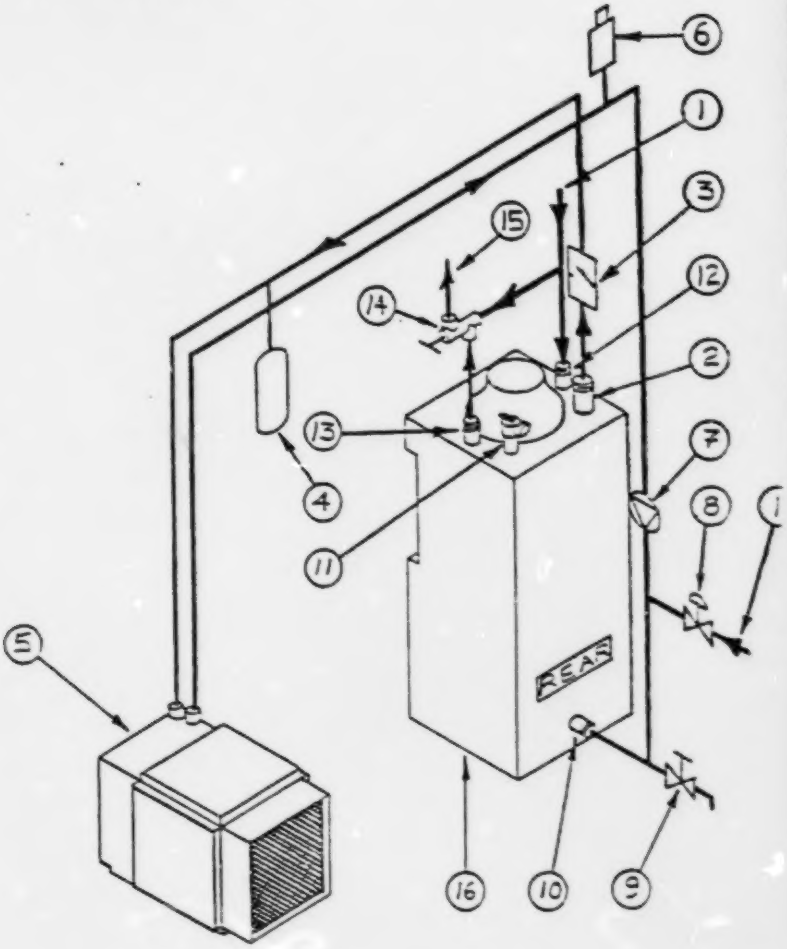


FIGURE 2.
Piping diagram
of system

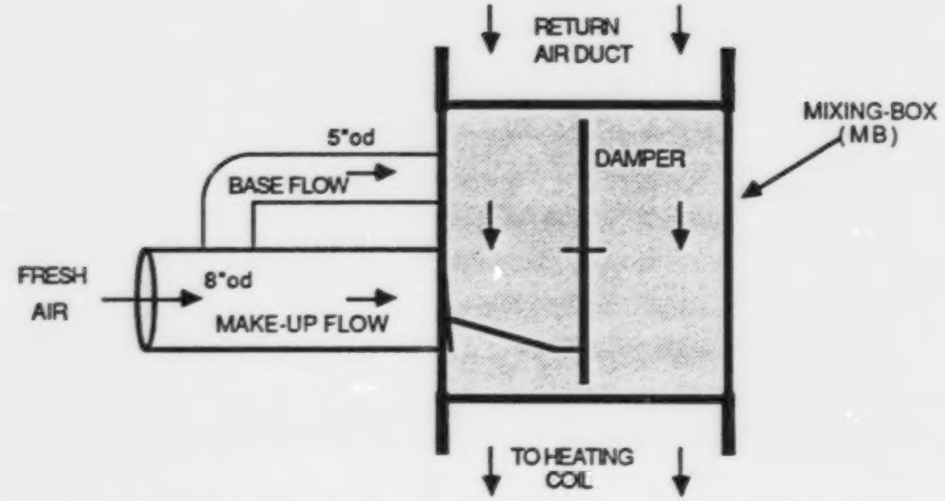

RETURN
AIR DUCT
MIXING-BOX
(MB)
5"od
BASE FLOW
DAMPER
FRESH
AIR
8"od
MAKE-UP FLOW
TO HEATING
COIL

FIGURE 3(a). Passive ventilation from return duct suction

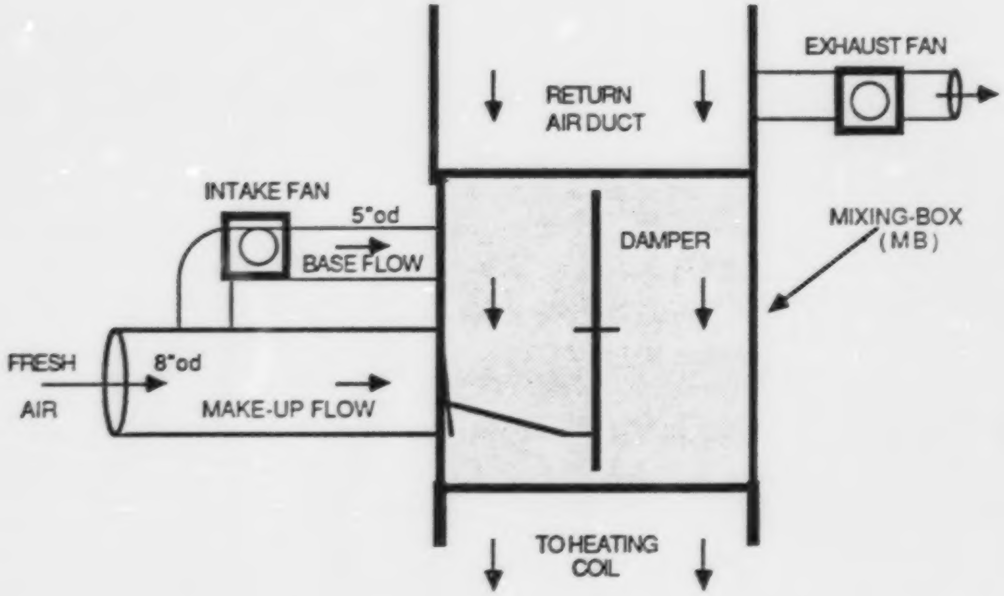

EXHAUST FAN
RETURN
AIR DUCT
INTAKE FAN
5"od
BASE FLOW
MIXING-BOX
(MB)
DAMPER
FRESH
AIR
8"od
MAKE-UP FLOW
TO HEATING
COIL

FIGURE 3(b). Fan-assisted ventilation

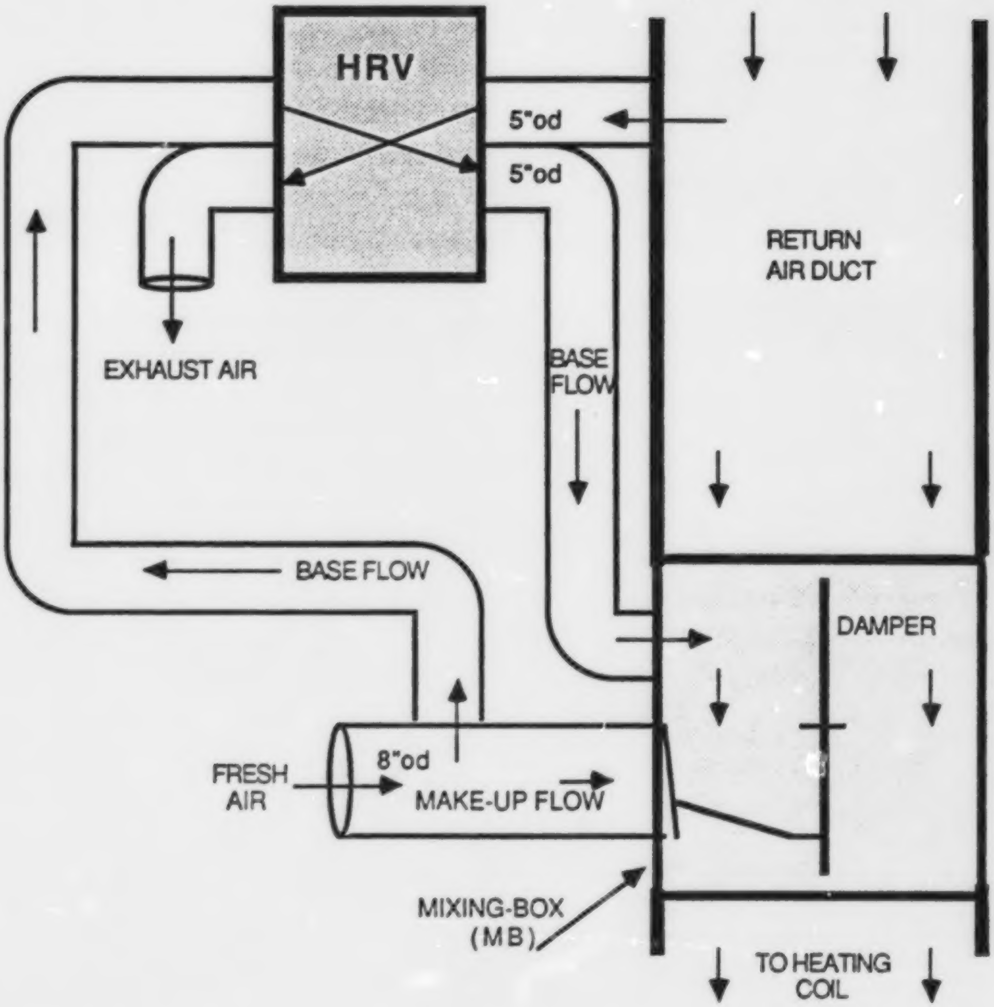

HRV
5"od
5"od
RETURN AIR DUCT
EXHAUST AIR
BASE FLOW
BASE FLOW
DAMPER
FRESH AIR
8"od
MAKE-UP FLOW
MIXING-BOX (MB)
TO HEATING COIL

FIGURE 3(c). Ventilation with a Heat Recuperation Ventilator (HRV)

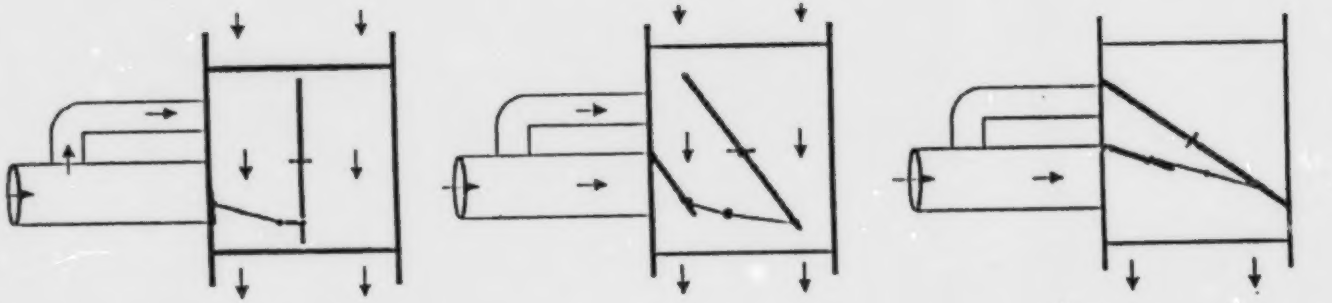


Figure 4(a)
No make-up air

Figure 4(b)

Figure 4(c)
Full make-up air

FIGURES 4(a...c)
Mixing-box operating sequence

INTEGRATED HEATING AND VENTILATION SYSTEM

SYSTEM AIR FLOW DATA

Operating Mode	make-up air damper	fanspeed	Intake L/s	exhaust L/s	make-up net L/s	Z1 supply L/s	Z2 supply L/s	Total circ L/s	fresh air %	make-up %
NORMAL	CLOSED	LS/LS	58	55	3	250	184	434	13%	1%
	CLOSED	HS/HS	58	49	9	386	266	652	9%	1%
MAKE-UP	OPEN	LS/LS	119	58	61	182	134	316	38%	19%
	OPEN	HS/HS	170	59	111	279	170	449	38%	25%
MAKE-UP	½OPEN	LS/LS	88	57	31	214	139	353	25%	9%
	½OPEN	HS/HS	120	55	65	335	190	525	23%	12%

FIGURE 5.
System air flow data

AIRFLOW.XLS

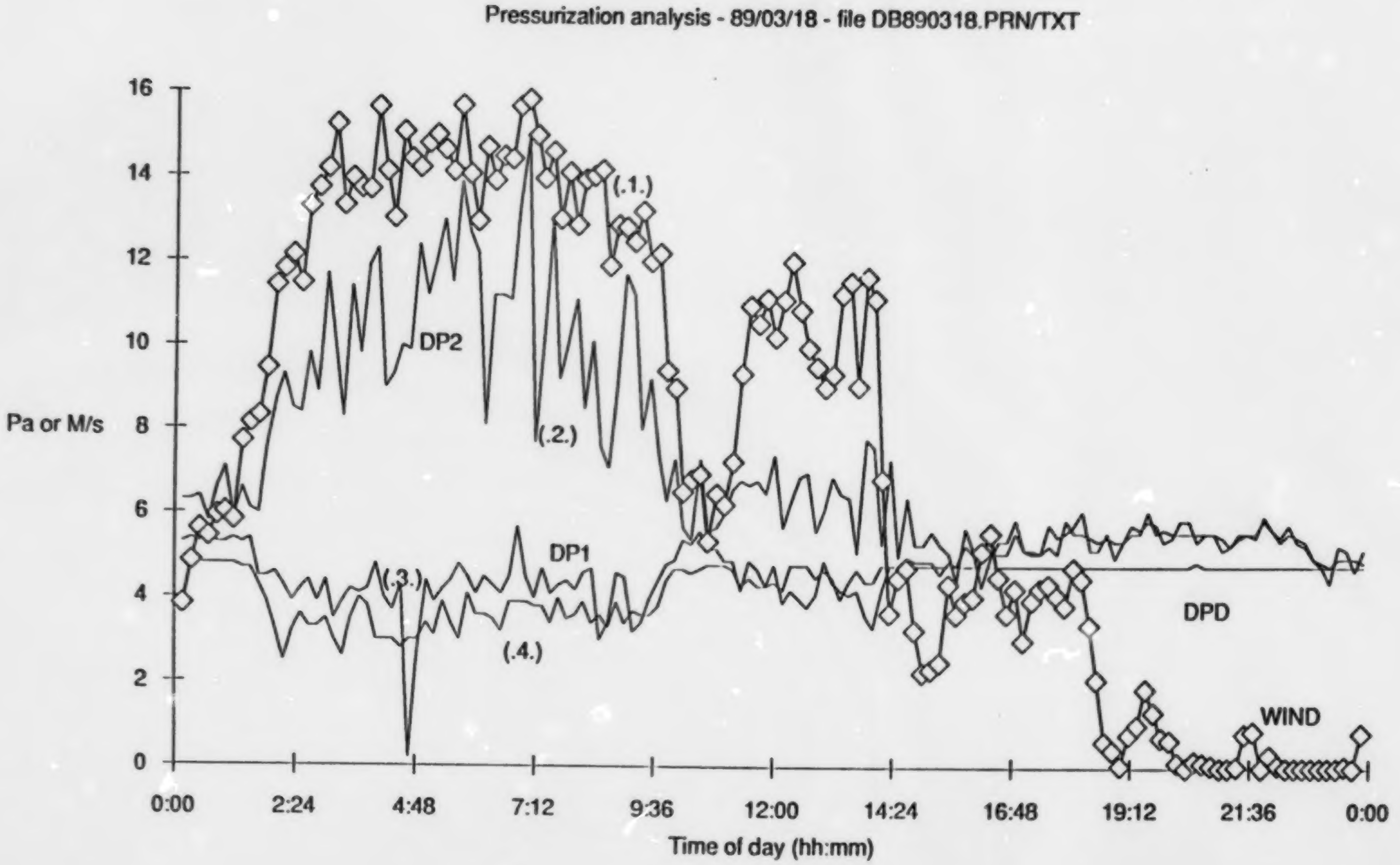


FIGURE 6.
Envelope pressure difference

PR890318.XLC

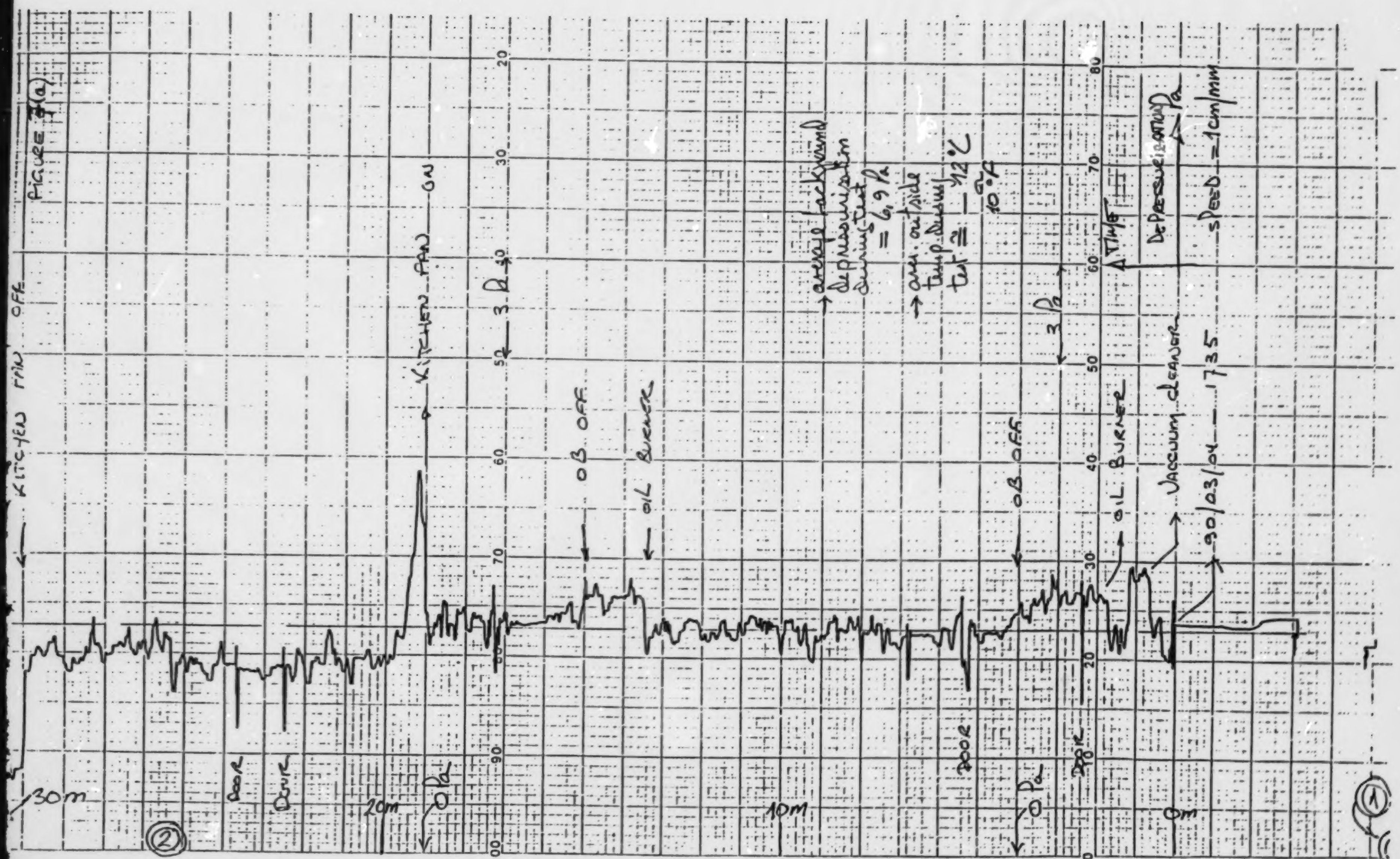


FIGURE 7(a).
Pressure compensation test

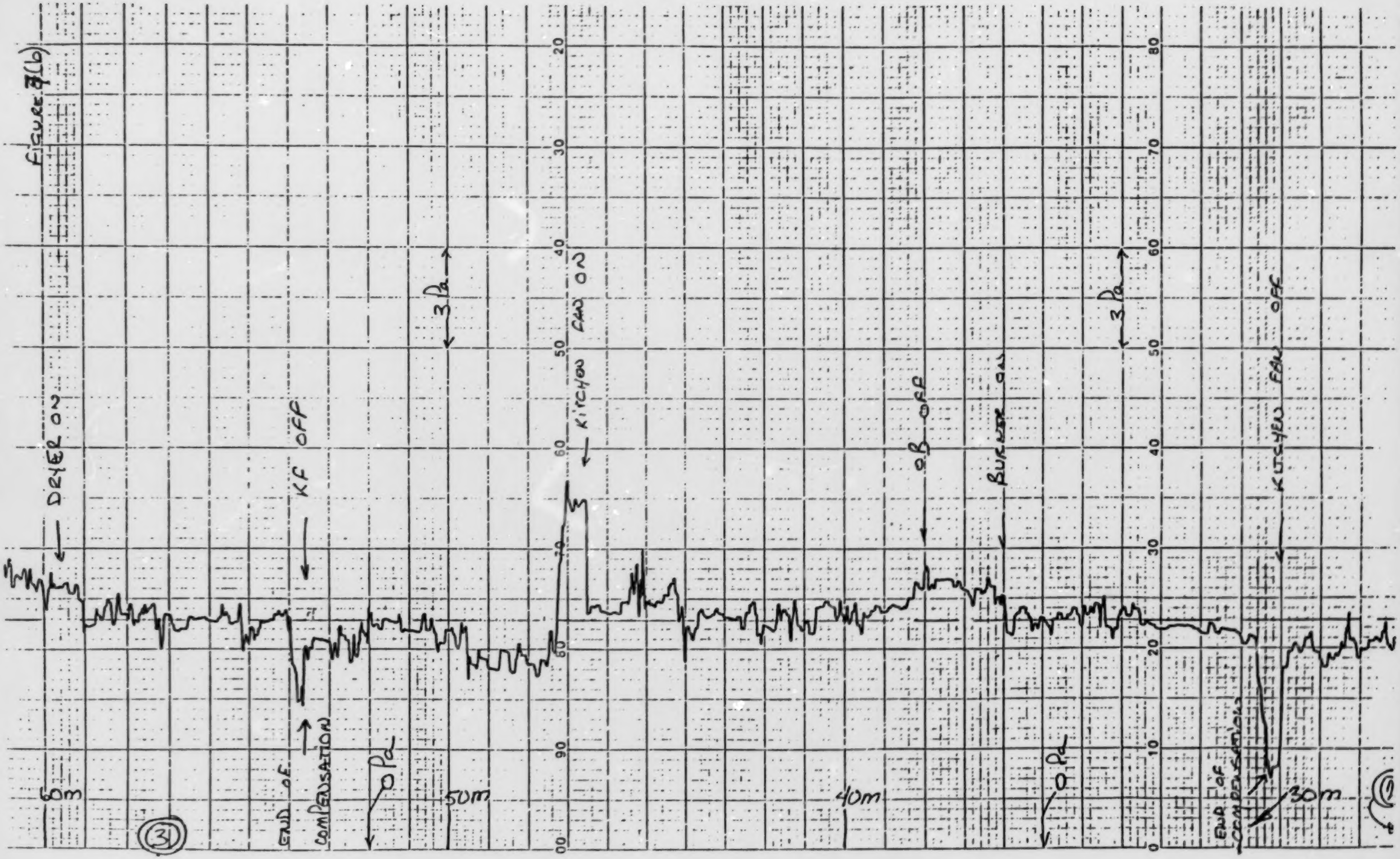


FIGURE 7(b).
Pressure compensation test

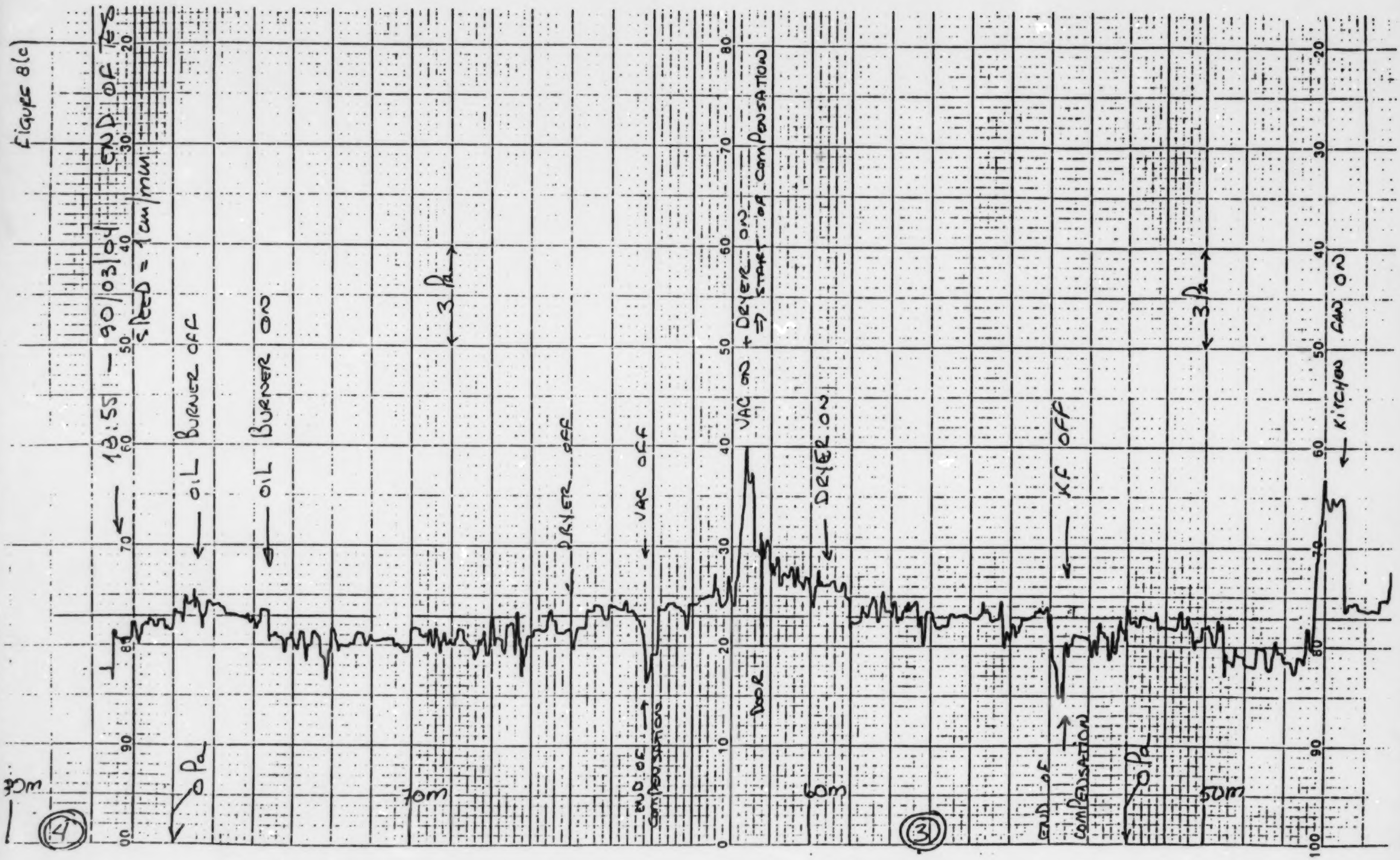


FIGURE 7(c).
Pressure compensation test

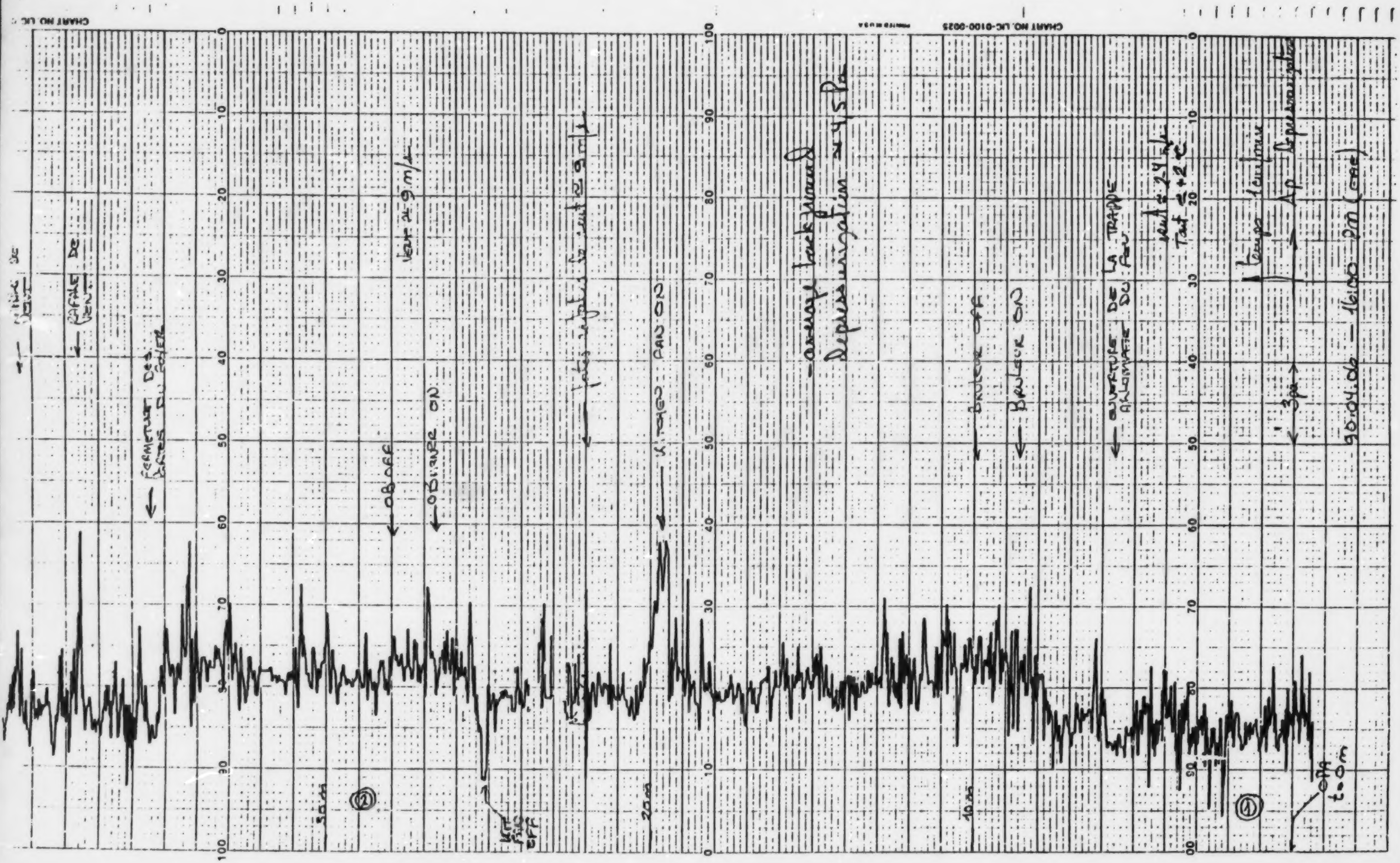


FIGURE 8(a).
Pressure compensation test
with fireplace operating

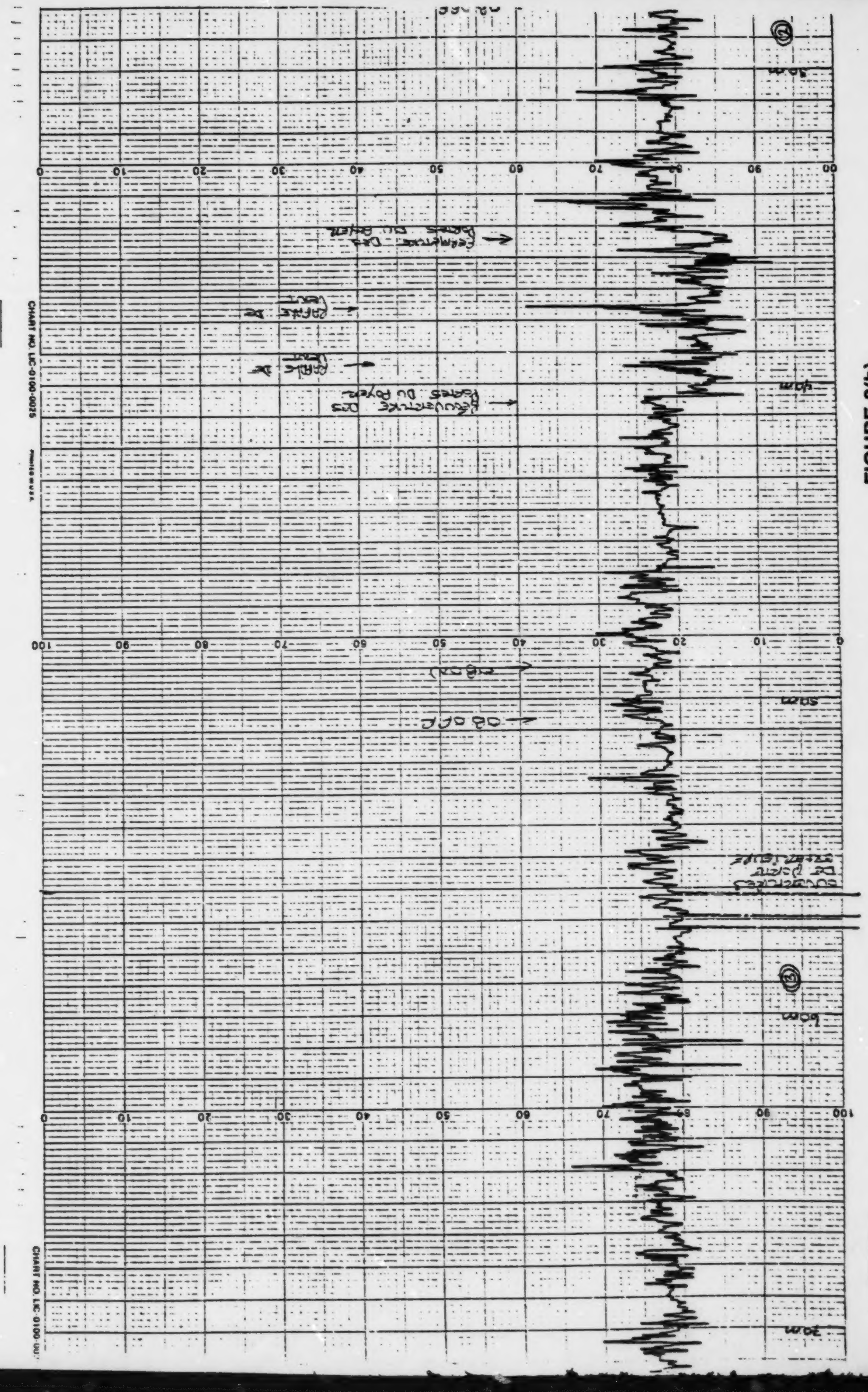


FIGURE 8(b).
Pressure compensation test
with fireplace operating

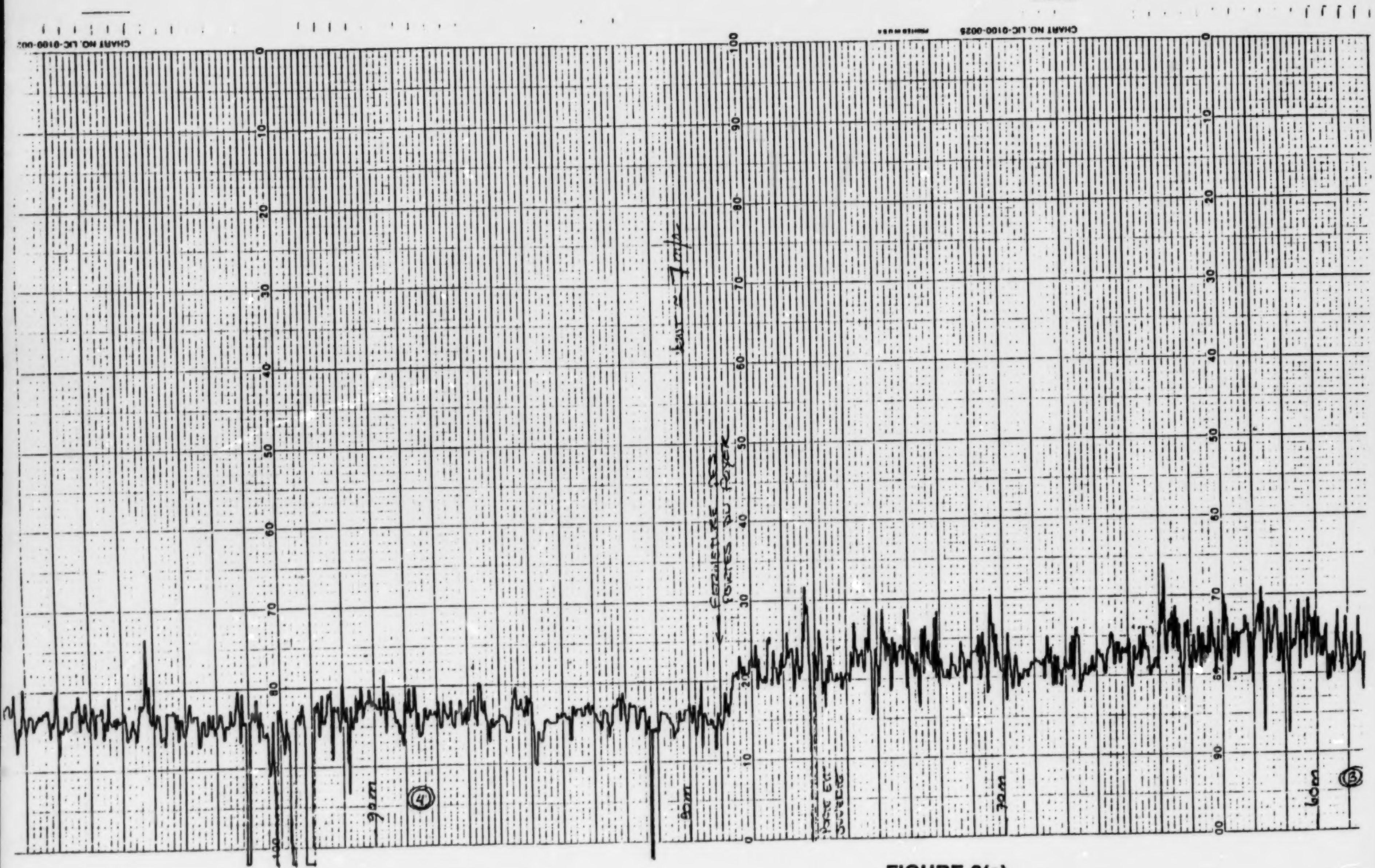


FIGURE 8(c).
Pressure compensation test
with fireplace operating

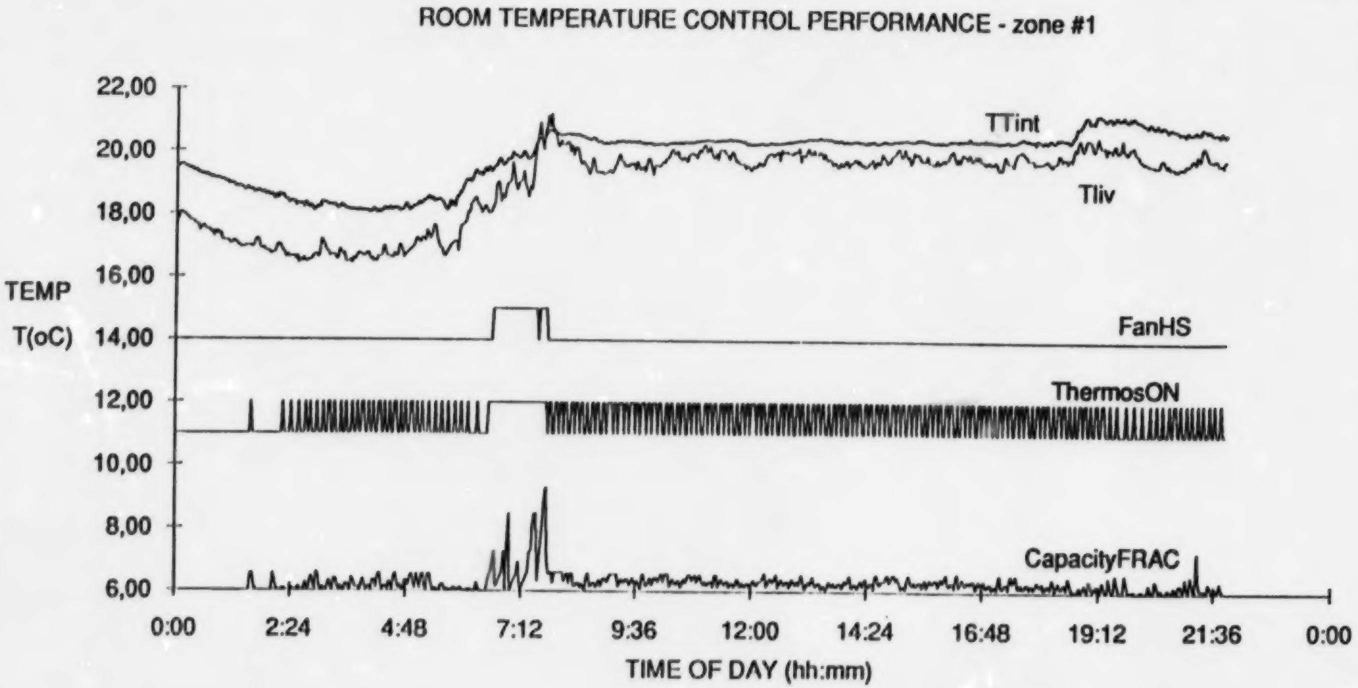


FIGURE 9(a).
Temperature control performance of system - Zone #1

Z1_NO24.XLC

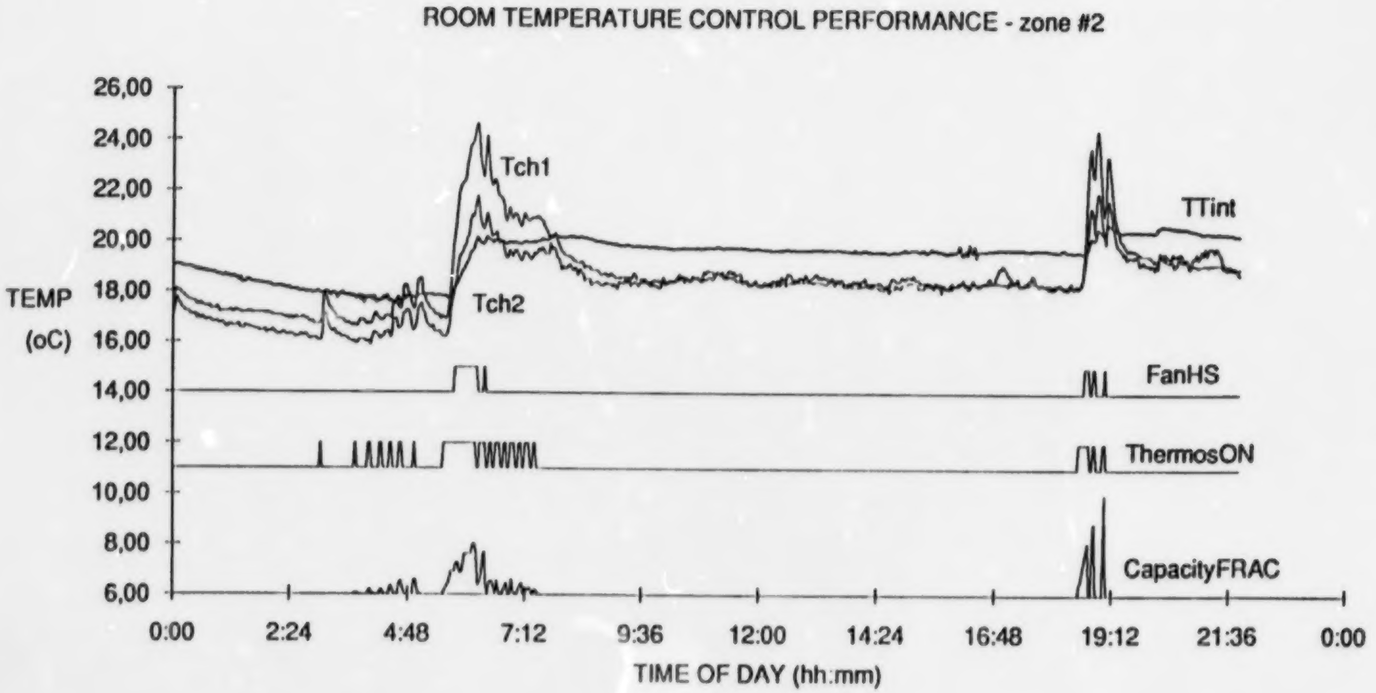


FIGURE 9(b)
Temperature control performance of system - Zone #2

Z2_NO24.XLC

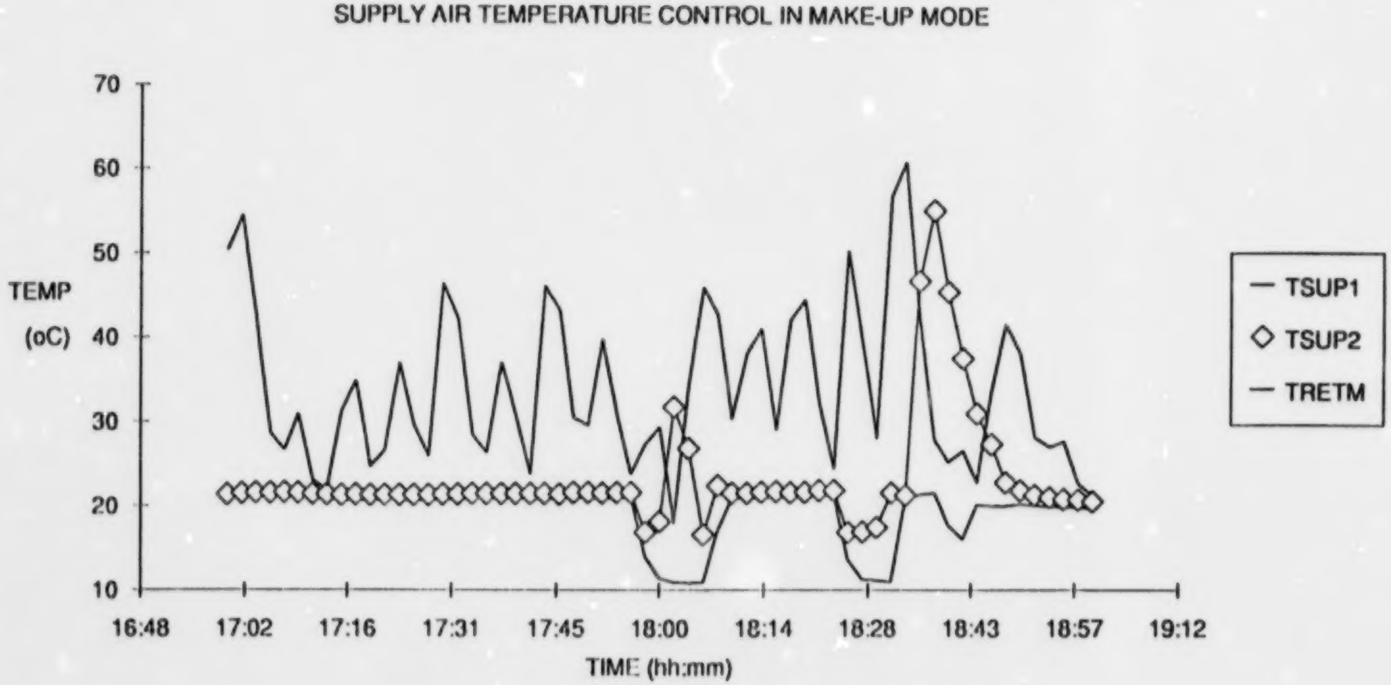


FIGURE 10.
Supply air temperature control

SUPTEMP.XLC

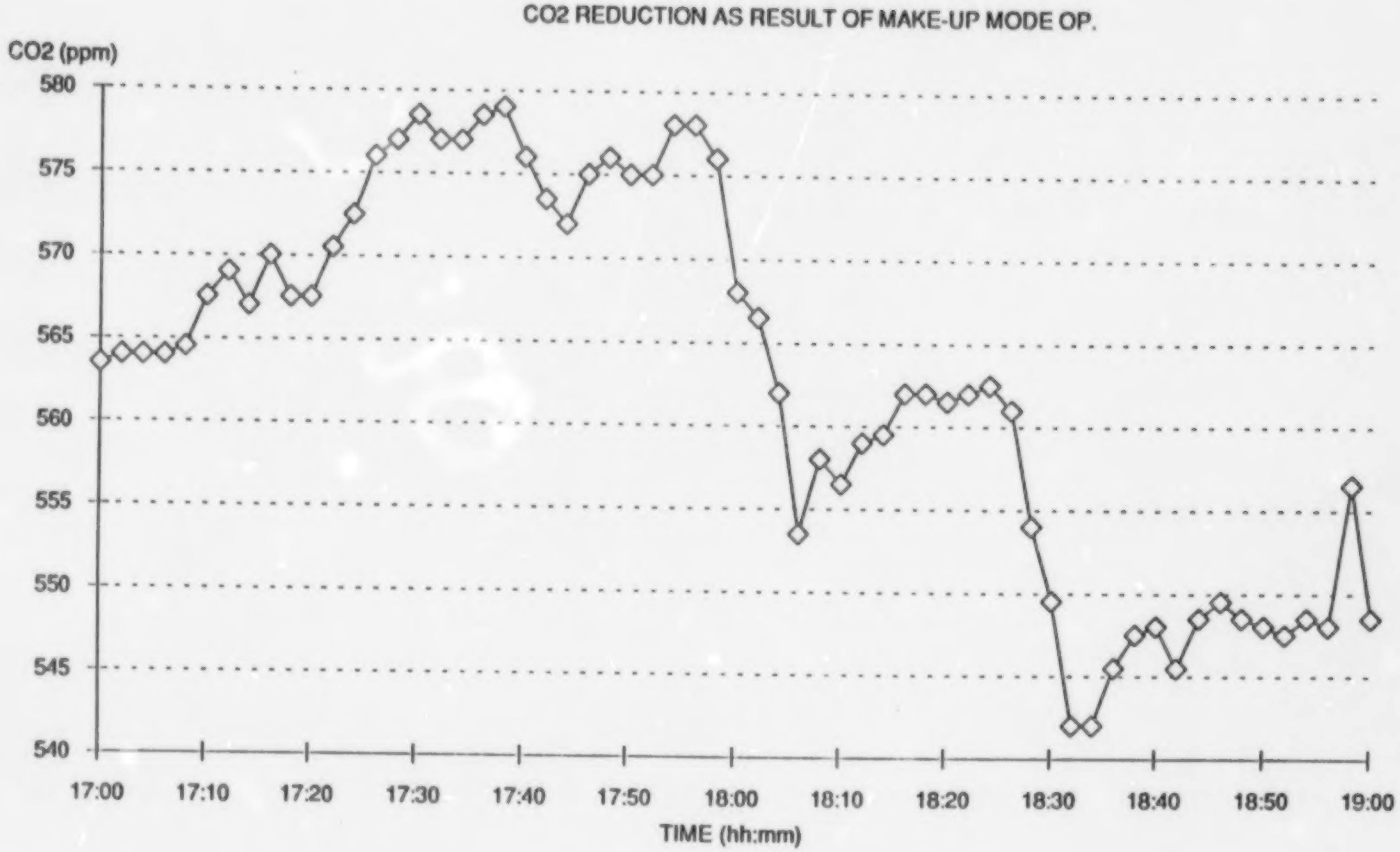


FIGURE 11.
CO2 reduction as a result of make-up mode operation

ZAZ0304C.XLC

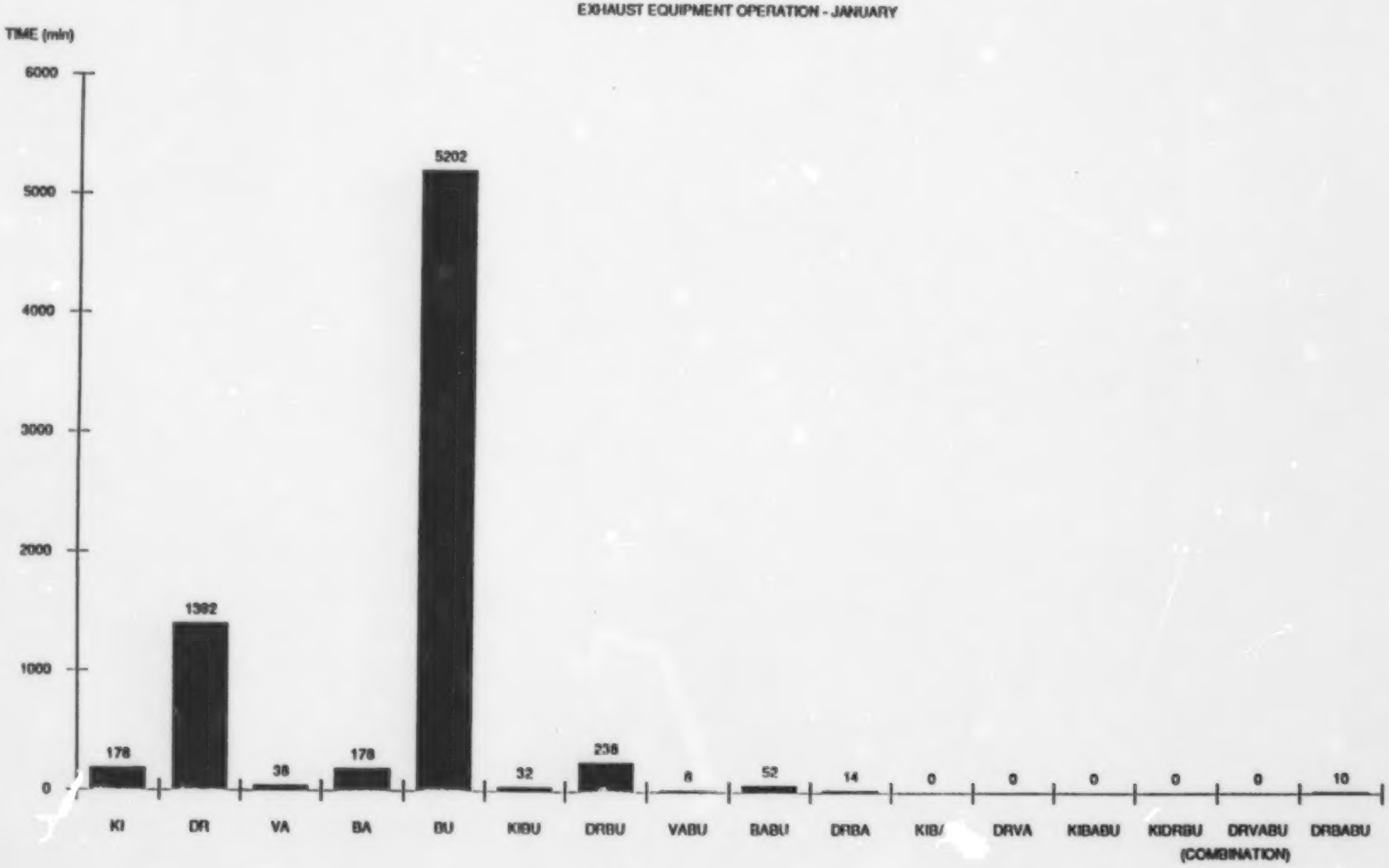


FIGURE 12.
Exhaust equipment operation
January

EXHAUJAN.XLC

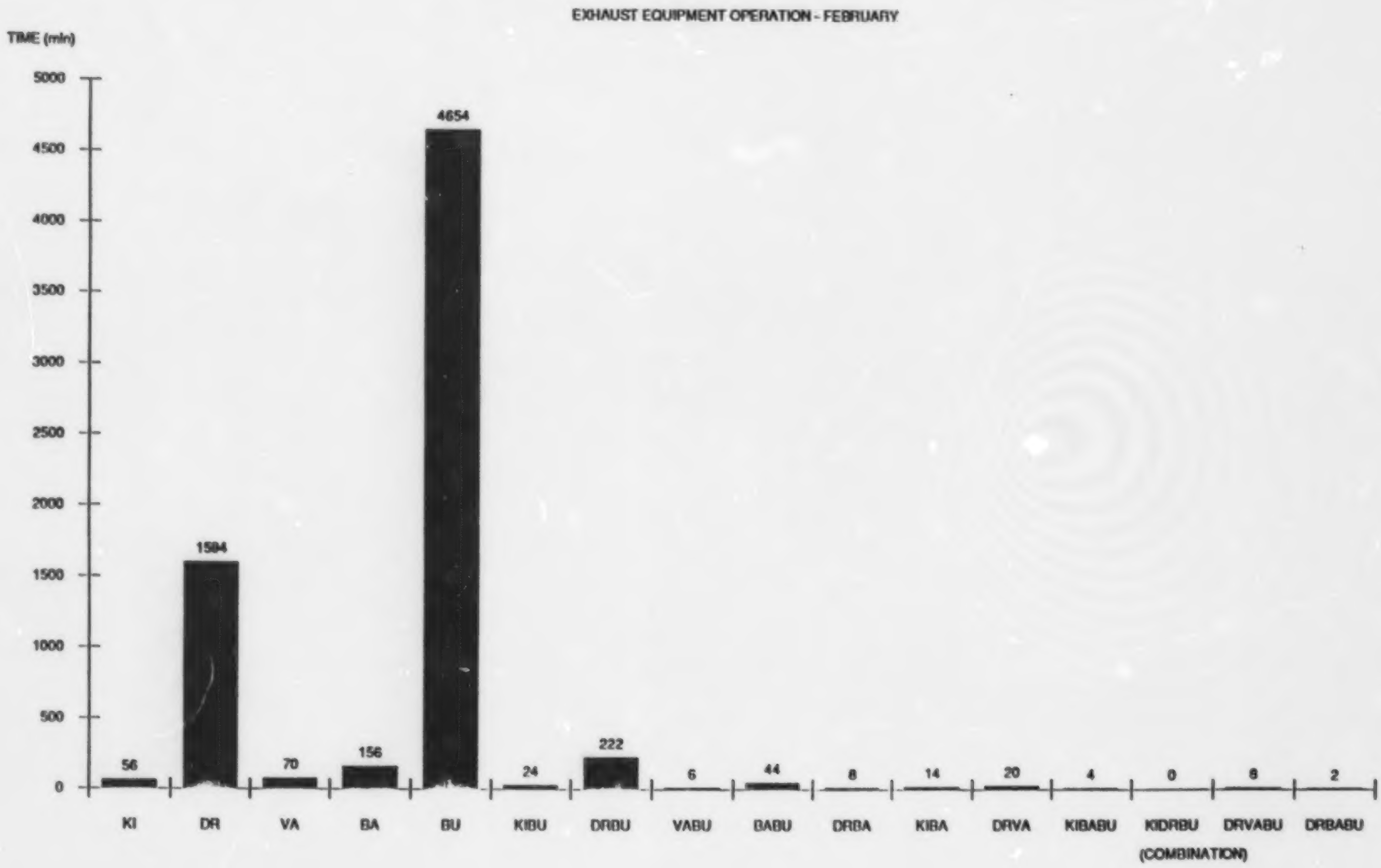


FIGURE 13.
Exhaust equipment operation
February

EXHAUFEB.XLC

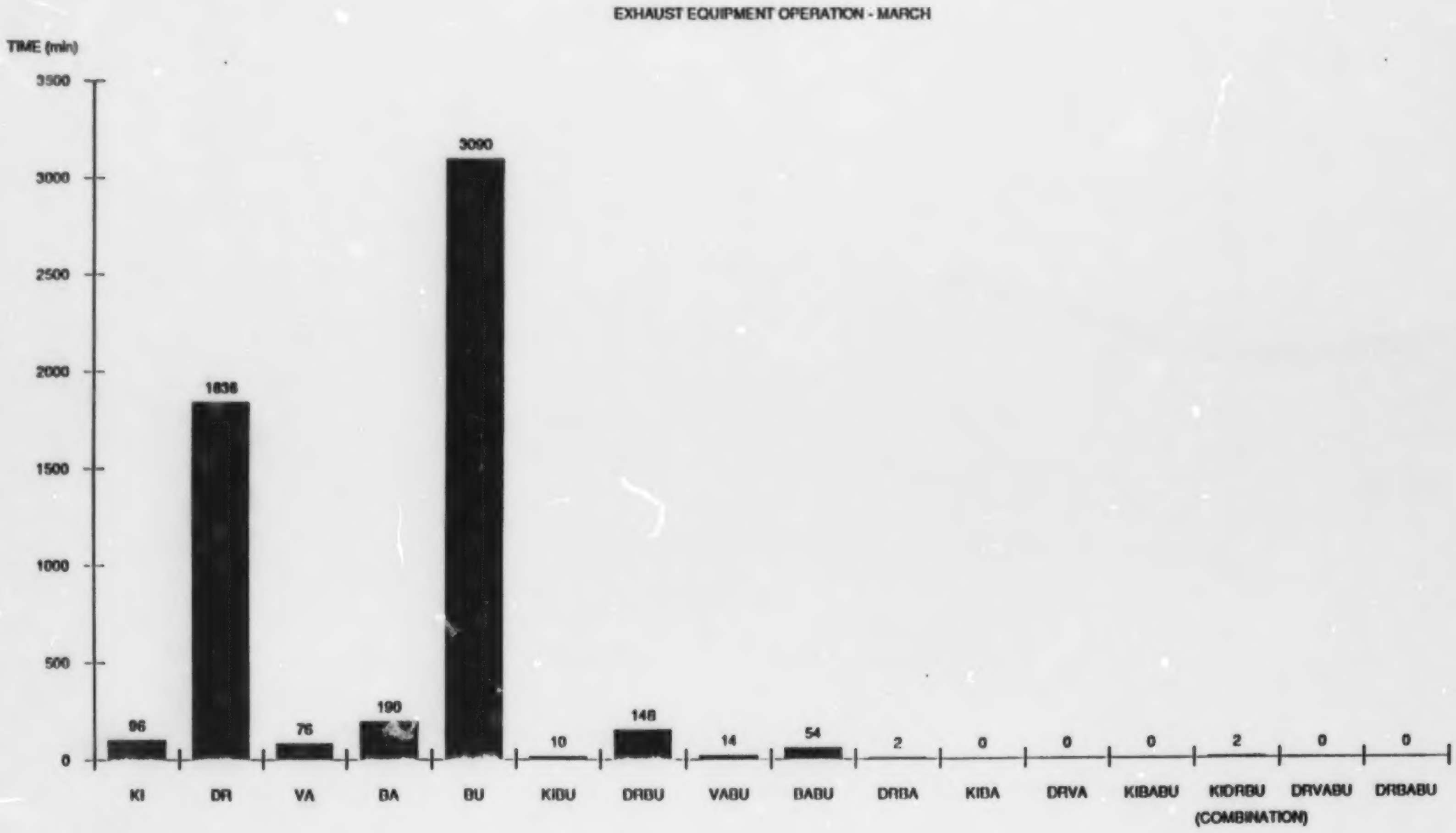


FIGURE 14.
Exhaust equipment operation
March

EXHAUMAR.XLC

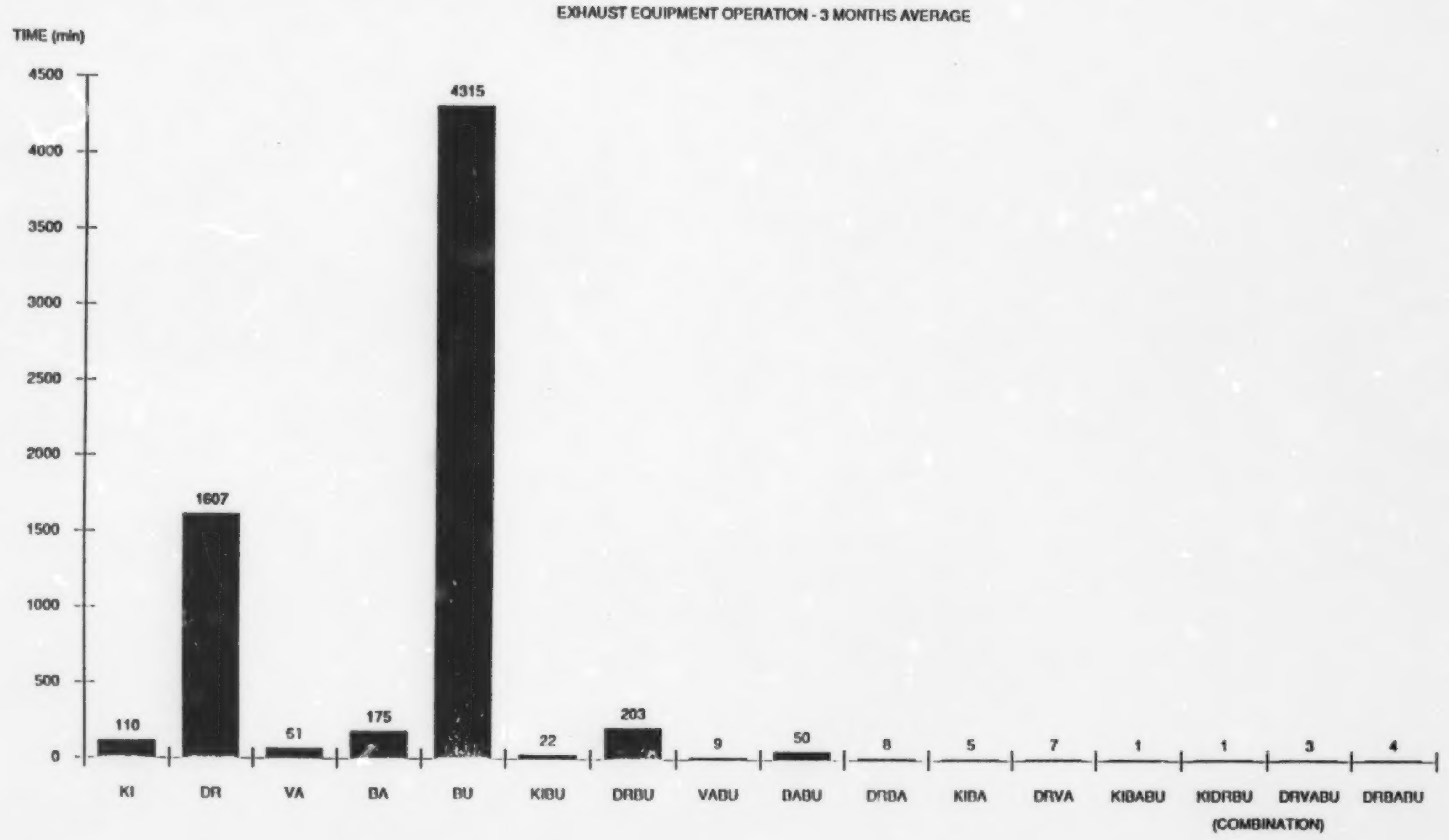


FIGURE 15.
Exhaust equipment operation
3-months average

EXHAVER.XLC

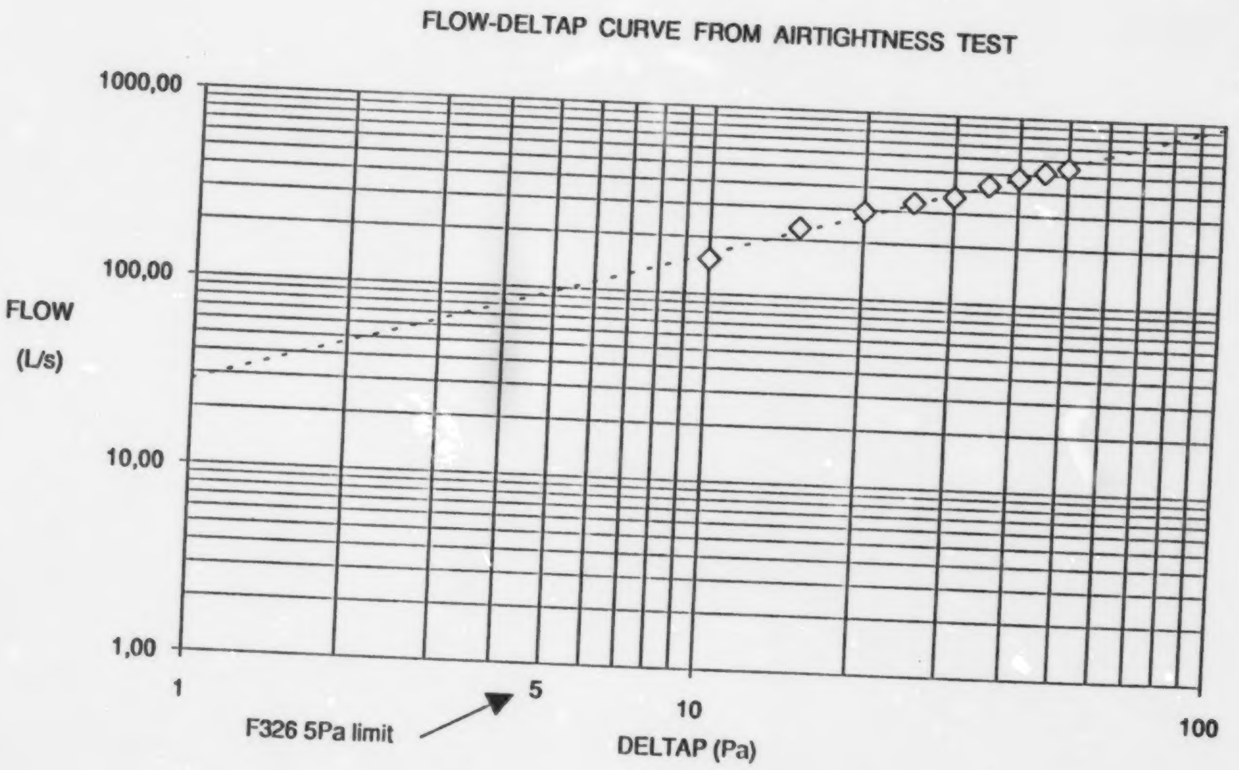


FIGURE 16.
Airtightness of test-home
Test pressure-flow curve

DELPTEST.XLC

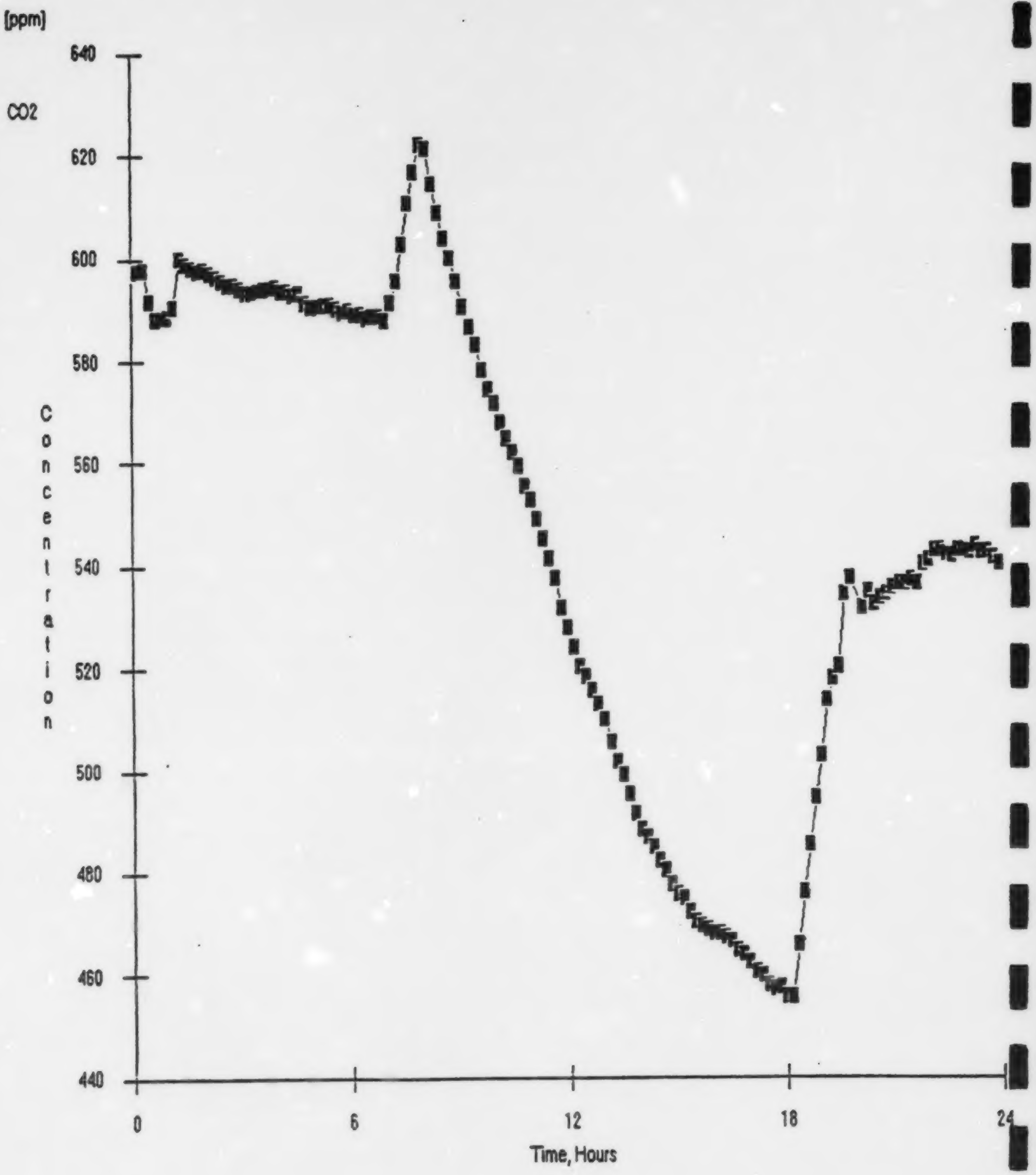


FIGURE 17(a).
Measured indoors CO2 concentration
March 1st, 1989

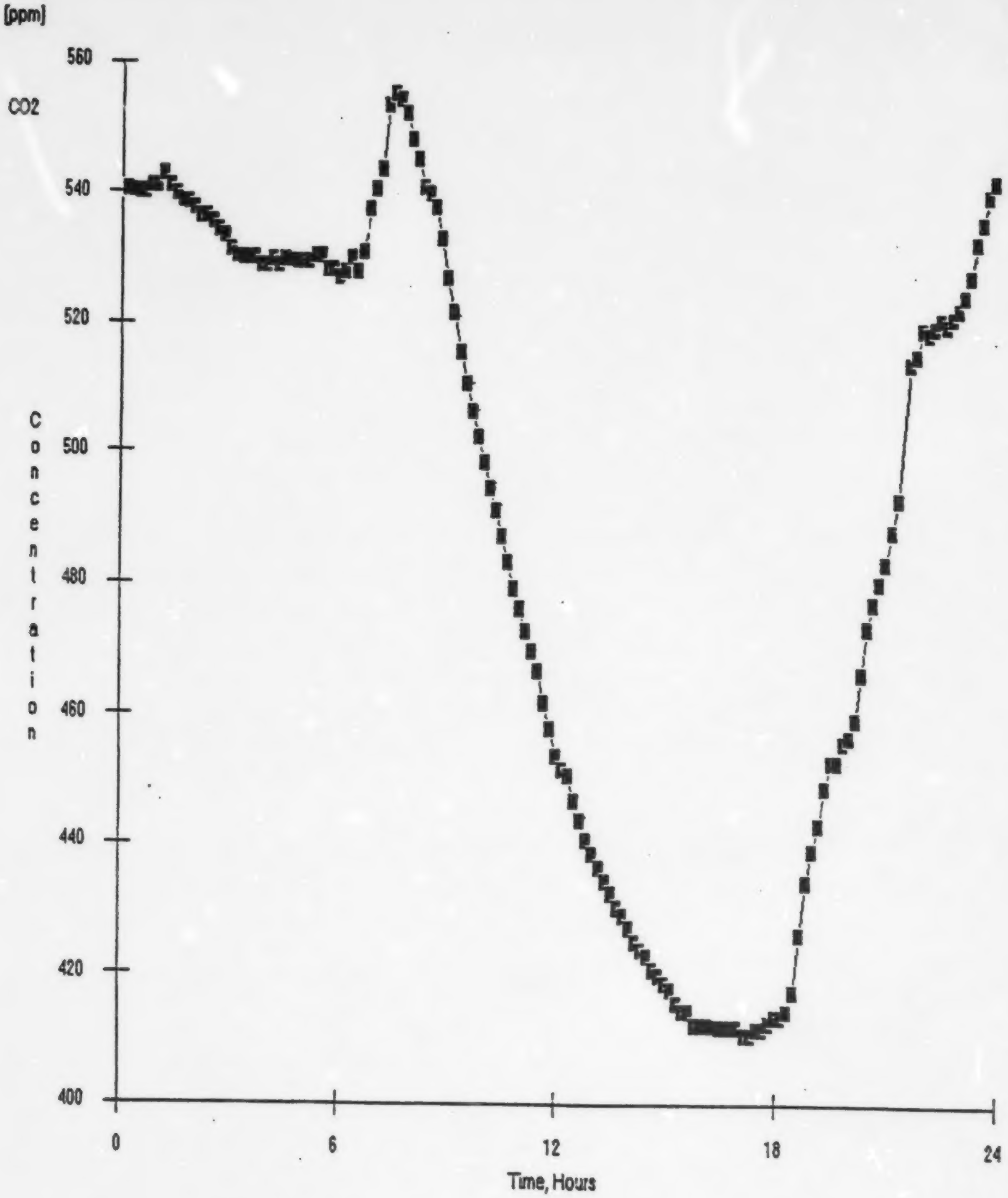


FIGURE 17(b).
Measured indoors CO2 concentration
March 2nd, 1989

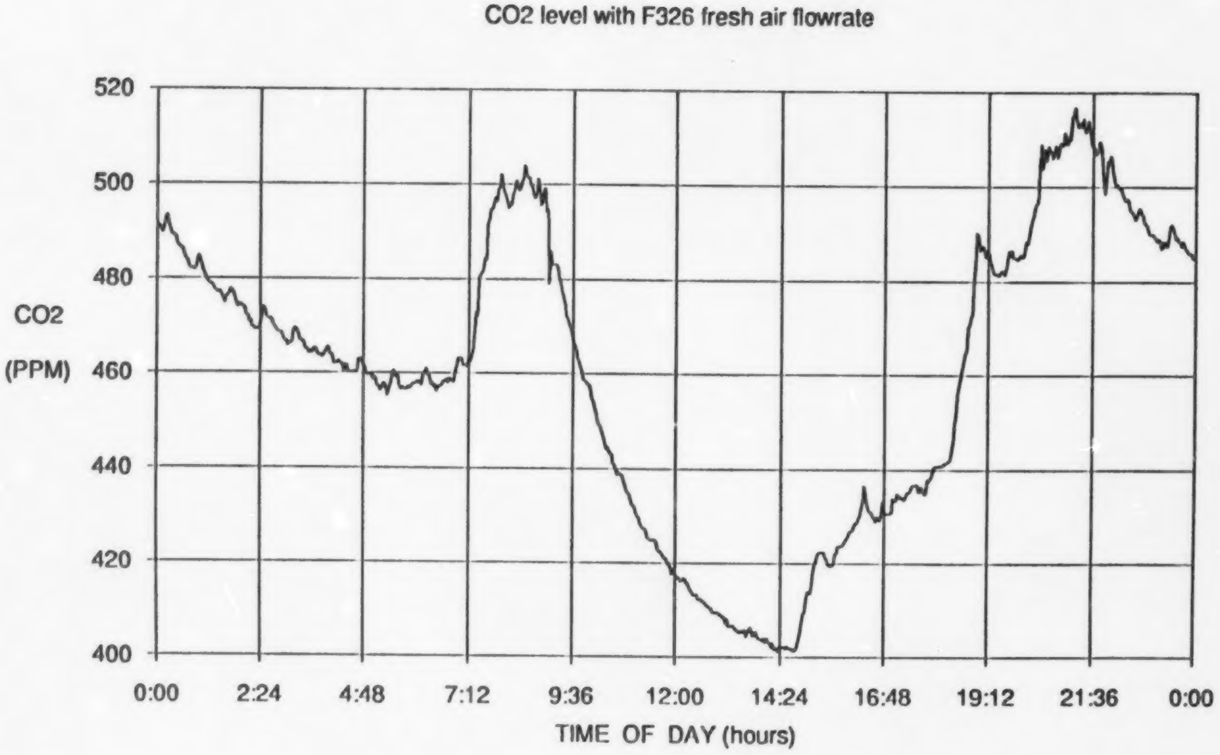


FIGURE 18.
Measured indoors CO2 concentration
February 26, 1990

CO2L0226.XLC

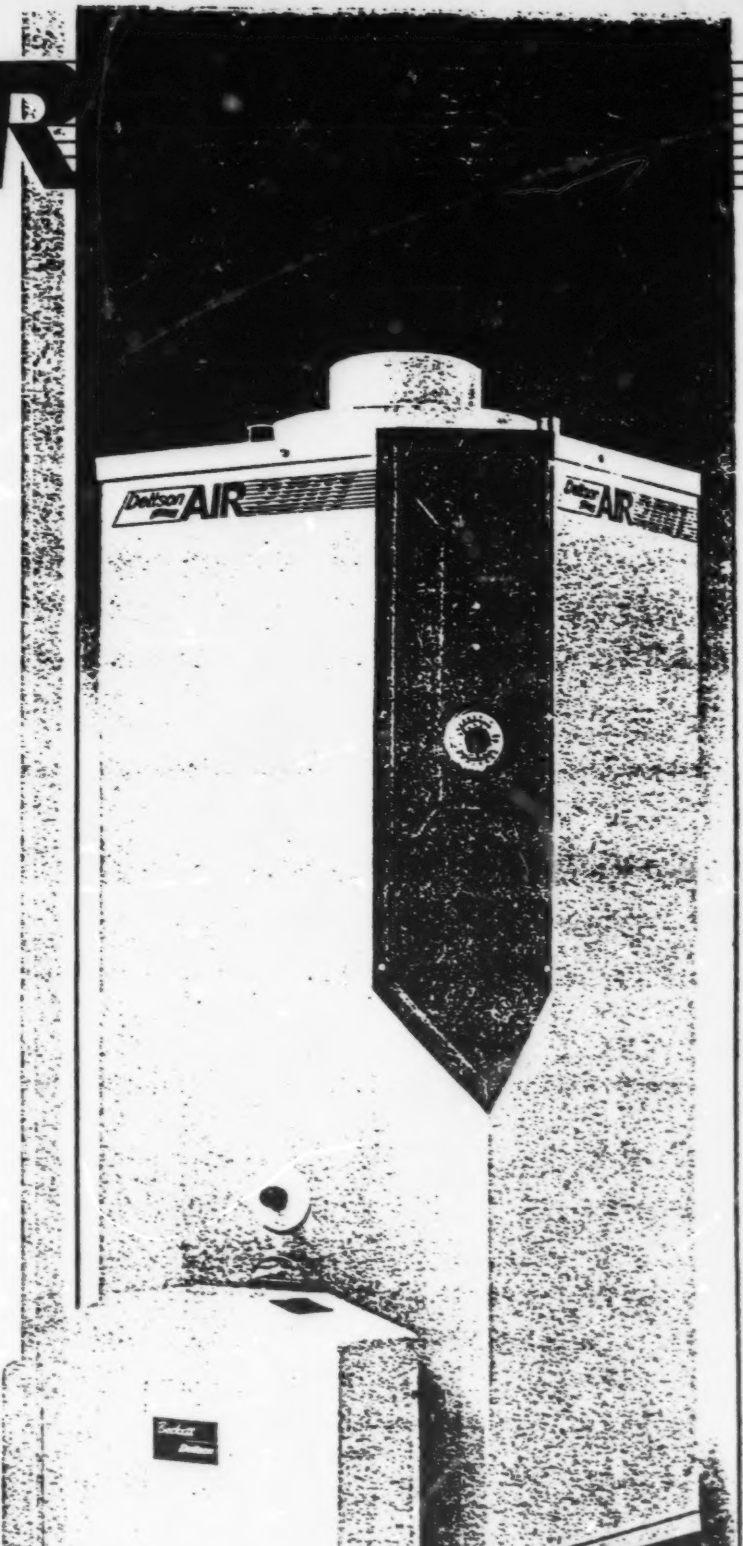
APPENDIX 1.
Technical documentation on commercial system

Dettson AIR

modèle **HMD**
HYDRONIQUE

Chaudière à eau chaude et chauffe-eau domestique

HAUTE EFFICACITÉ
MAZOUT



- Chauffage hydronique et eau domestique sans compromis
- Eau chaude à volonté
- Capacité de chauffage 124 MBH à 235 MBH
- Dégagement d'eau domestique de 154 gallons à 265 gallons à 100°△T
- Réservoir en acier inoxydable
- Installation avec ou sans cheminée
- Equipée d'un brûleur haute technologie Dettson/Beckett.
- Chambre à combustion entourée d'eau
- Entretien minimum
- Propre
- Compact
- Style futuriste

Garantie 10 ans

(Voir manuel d'installation)

Le respect de la qualité, un gage de fiabilité.

Caractéristiques techniques
Modèle HMD

Modèle	Volume eau, T = 100°F Par heure en gallons imp.	Capacité (MBH)	Brûleur	Gicleur Angle et modèle	Pression (PSI)	Poids
HMD-124 B	154	124	AFG MD-V1	1,00 70-S	100	412 lb. - 187 kg.
HMD-135 B	165	135	AFG MD-V1	1,10 70-S	100	412 lb. - 187 kg
HMD-146 B	176	146	AFG MD-V1	1,20 70-S	100	412 lb. - 187 kg
HMD-163 B	193	163	AFG MD-V1	1,33 70-S	100	412 lb. - 187 kg
HMD-179 B	209	179	AFG MD-V1	1,50 70-S	100	412 lb. - 187 kg
HMD-208 B	238	208	AFG MD-V1	1,75 70-S	100	412 lb. - 187 kg
HMD-235 B	265	235	AFG MD-V1	2,00 70-S	100	412 lb. - 187 kg

1. Chaudière isolée
- Une enveloppe isolante recouvre tous les côtés de la chaudière et réduit les pertes de chaleur à moins de 0,5%.

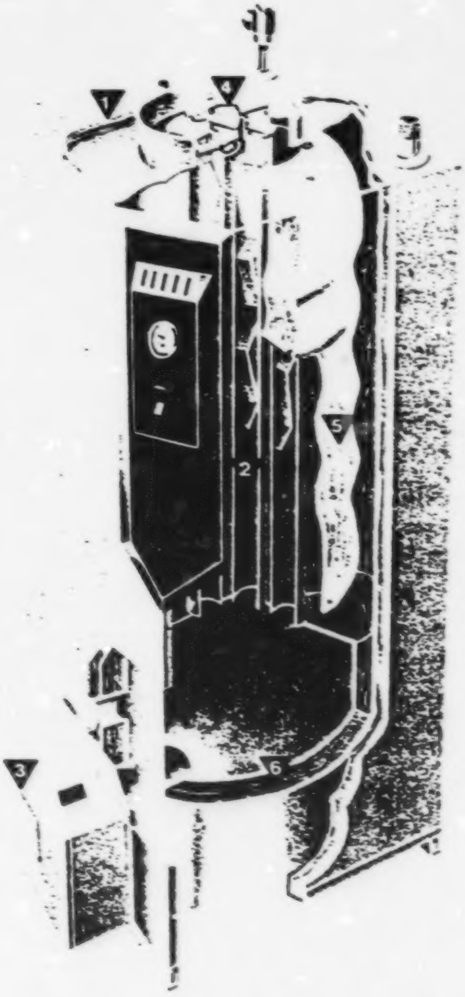
2. Tubes de fumée verticaux
- Retiennent les gaz à l'aide de déflecteurs en acier inoxydable.
- Permettent d'abaisser la température des gaz.

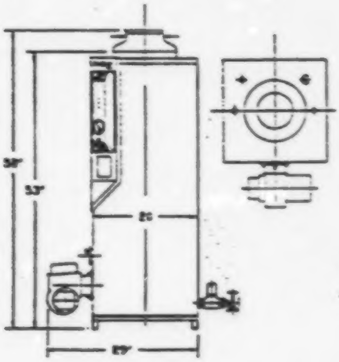
3. Brûleur à tête de rétention
- Beckett/Dettson*.
- Permet une combustion complète du combustible.
- Assure un haut rendement et une grande efficacité.

4. Sortie des gaz
- Température réduite augmentant l'efficacité de l'appareil sans accroître les risques de condensation.

5. Chauffe-eau indirect en acier inoxydable massif
- Grande production d'eau chaude.
- Evite l'encombrement et les frais d'installation d'un chauffe-eau ordinaire.
- Réduit les coûts d'utilisation en combinant chaudière et chauffe-eau.

6. Foyer refroidi à l'eau
- Augmente la surface de chauffe.
- Ne comprend aucun produit réfractaire.
- Permet à la chambre de combustion de durer aussi longtemps que la chaudière.
- Réduit les bruits causés par la turbulence.
- Elimine les pertes de chaleur par la base de la chaudière.





HAUTE EFFICACITÉ

Dettson
3400, boul. Industriel
Sherbrooke (Québec)
J1L 1V8
Téléphone: (819) 567-8493
Télécopieur: (819) 822-4227

Compagnie du Groupe
Multi-Ind

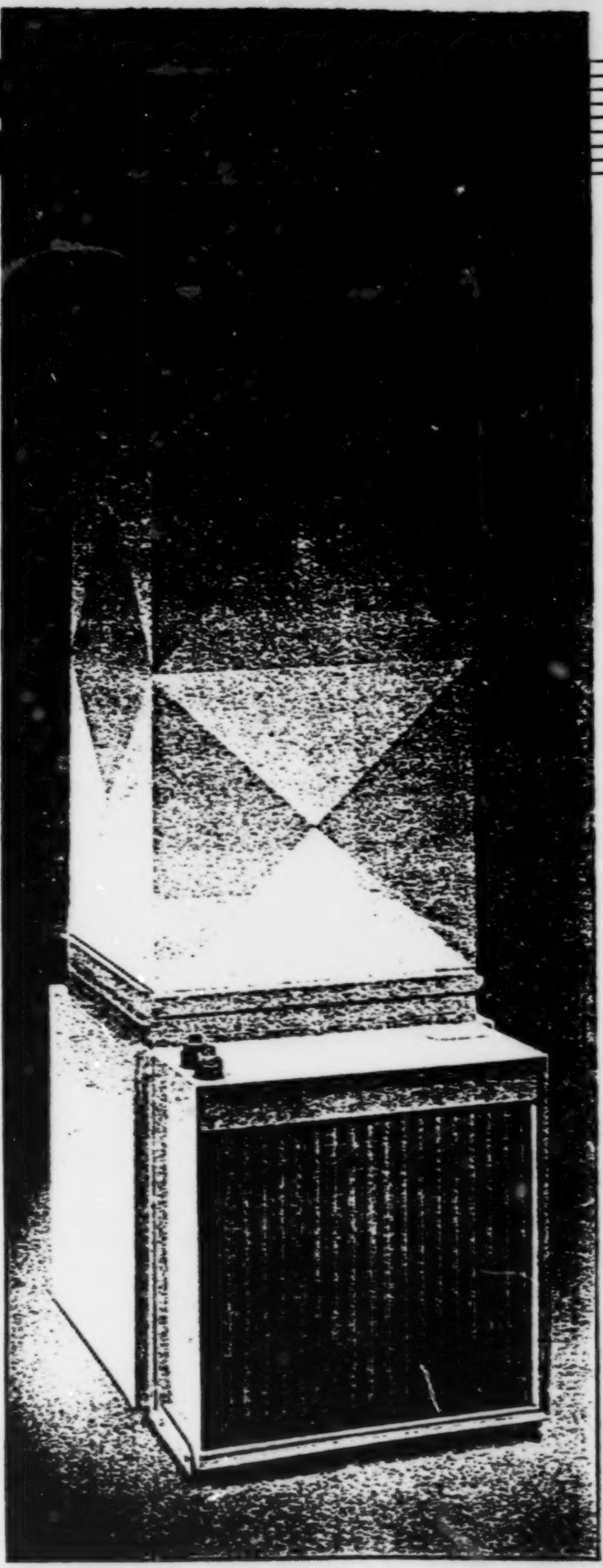
X00629

LITHO CANADA

Dettson AIR

model **FC**

Heating-Ventilation Unit



- This unique design allows for variations in water and heat flow, proportional to energy losses. This helps to keep temperatures constant at all times.
- Low speed and quiet operation (with 2-speed motor).
- Air quality is far superior to conventional forced-air systems.
- The thermal and acoustic insulation of the cabinet is one of the many advantages of this system.
- Monocoque construction eliminates vibrations.
- Runs slowly and quietly.
- The system adapts well to most installation requirements.
- With the option:
  - 2-speed motor
  - high static pressure
  - Dust Eater air filter

10-year warranty

(See Installation Manual)

The respect for quality, a guarantee of reliability.

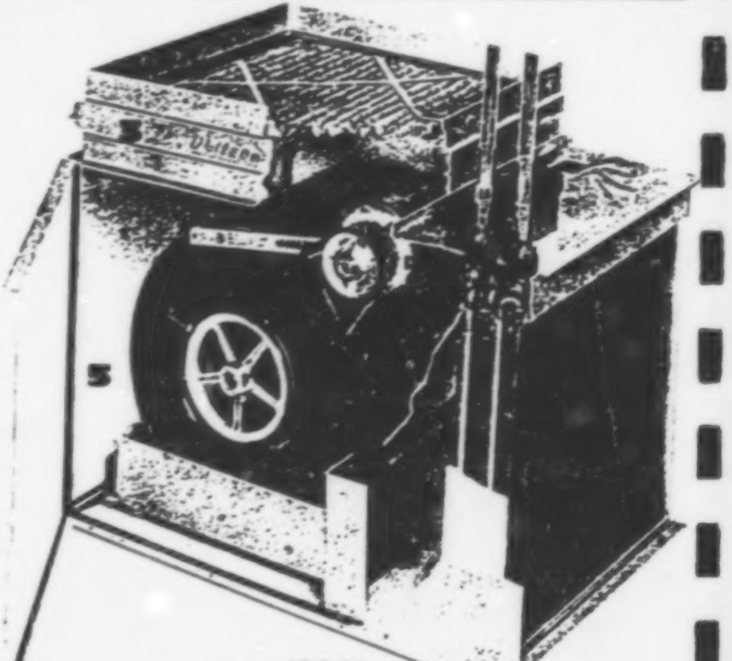
Technical Data

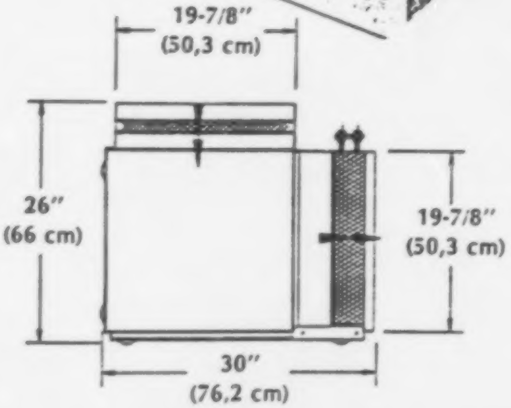
Heating-ventilation units available

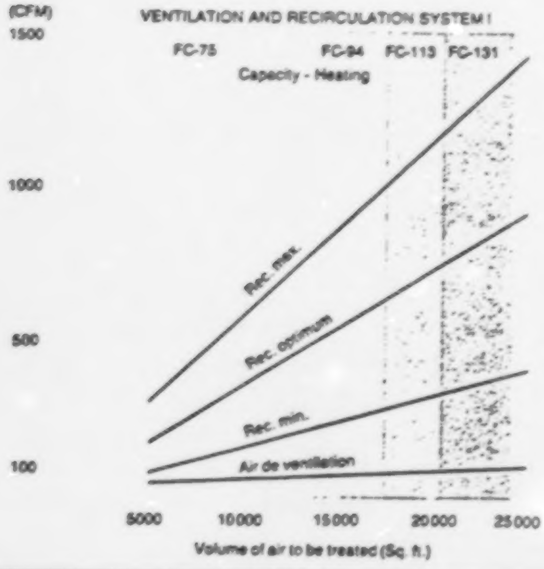
Dettson AIR

Model	Maximum capacity (MBH)	CFM Low speed	CFM High speed	Static pressure (WC)	Delta T (°F)	Motor (HP)	Pulley Motor (inch)	Pulley Fan (inch)	Weight Lbs / Kg
FC-75	74,8	540	800	0,20	85	1/3	3-1/2	7	135 / 62
FC-75-HPS	74,8	540	800	0,40	85	1/3	3-1/2	7	135 / 62
FC-94	93,5	670	1000	0,20	85	1/3	3-1/2	7	135 / 62
FC-94-HPS	93,5	670	1000	0,40	85	1/2	3-1/2	6	135 / 62
FC-113	112,2	800	1200	0,20	85	1/2	3-1/2	6	135 / 62
FC-113-HPS	112,2	800	1200	0,40	85	3/4	3-1/2	5	135 / 62
FC-131	130,9	940	1400	0,20	85	3/4	3-1/2	5	135 / 62

1. **Fan**
   - Runs slowly and quietly (optional).
2. **Motor**
   - The 1-speed motor is standard equipment.
3. **Filter flange**
   - The top quality conventional filter is designed to operate 24 hours a day.
   - The filter drawer slides out to provide easy access.
4. **Convector**
   - This unique design allows for variations in water and heat flow, proportional to energy losses. This helps to keep temperatures constant at all times.
   - Air quality is far superior to conventional forced-air systems.
5. **Frame**
   - The thermal and acoustic insulation of the cabinet is one of the many advantages of this system.
   - Monocoque construction helps eliminate vibrations.
   - The system adapts well to most installation requirements.







Dettson

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Fax: (819) 822-4227

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Graphics & Communications Services

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LITHO CANADA

APPENDIX 2.
Installation, maintenance and operation manual

MANUEL D'INSTALLATION D'ENTRETIEN ET D'OPERATION

SYSTEME DE CONFORT CENTRAL INTEGRE

AIR 2001

Cette brochure est expediee avec votre systeme et doit etre conservee pour reference lors de l'installation, de l'entretien et de l'operation du systeme

Dettson

550 Boul. Industriel,
C.P. 2087,
Sherbrooke, QC
J1J 3Y1
(819)567-8493

X-00415

Section 1 Introduction au concept AIR-2001

1.1 Le concept

DETTSON AIR 2001 est un système qui assure la gestion intégrée de l'ensemble des besoins énergétiques résidentiels à l'exception de l'éclairage et des appareils électro-ménagers. Le système assume donc les fonctions suivantes: chauffage / climatisation, eau chaude sanitaire, ventilation et conditionnement de l'air.

Au besoin, un serpentin de climatisation provenant d'un climatisateur central peut être ajouté à la sortie de l'unité de ventilation. L'ensemble est placé sous le contrôle d'un micro-processeur, véritable cerveau électronique qui organise la gestion des diverses fonctions de l'appareil.

La contrainte générale ayant sous-tendu la conception su système AIR 2001 est d'assumer le CONFORT TOTAL des usagers.

Au niveau des fonctions de chauffage, le CONFORT TOTAL implique de limiter au minimum les écarts de température dans le temps et dans l'espace, ainsi que d'assurer un temps de récupération rapide lors d'une élévation soudaine de la température du thermostat. Accessoirement, AIR 2001 permet d'opérer sur deux (2) zones de chauffage. Pour rencontrer ces contraintes, AIR 2001 assure une circulation continue, à basse vitesse et à température constante, la température de consigne pouvant être maintenue à 1 degré F près en régime stationnaire. On réduit ainsi substantiellement les effets de stratification pour une pièce donnée et les écarts de température entre les pièces plus chaudes (ensoleillement, présence d'un foyer, ...) et les autres pièces.

Par ailleurs, le système AIR 2001 dispose d'une capacité de chauffage variable et "auto-ajustable" de 0 à 130,000 BTU/H , ce qui permet, en régime stationnaire, d'opérer à une capacité de chauffage correspondant exactement à la déperdition thermique de la résidence, dans le contexte climatique précis où elle se trouve à un instant donné. En régime de récupération, le système opère à sa puissance maximale, ce qui permet une élévation rapide de la température ambiante, corrigeant ainsi les carences usuellement reprochées à un système de type conventionnel.

Au niveau de l'eau chaude sanitaire, le CONFORT TOTAL requiert d'assurer sa disponibilité en quantité abondante, de façon à satisfaire la consommation simultanée d'un bain, d'une douche et des appareils ménagers. Pour ce faire, AIR 2001 dispose d'une grande capacité de récupération provenant d'un échangeur en acier inoxydable.

Au niveau de la ventilation, le CONFORT TOTAL nécessite d'assurer un renouvellement continu en air frais correspondant à plus de 0.3 changement d'air par heure selon la norme F326 de l'ACNOR, tout en assurant un réchauffement de l'air d'entrée.

Mentionnons enfin que AIR 2001 peut être installé avec un système mural d'évacuation des gaz de combustion permettant de faire ainsi l'économie d'une cheminée.

1.2 Composantes du système

1.2.1 HWD Chaudière et chauffe-eau

- Chauffage hydronique et eau domestique
- Eau chaude à volonté
- Réservoir en acier inoxydable
- Installation avec ou sans cheminée
- Équipée d'un brûleur haute technologie Dettson/Beckett.
- Chambre à combustion entourée d'eau

1.2.2 Unité de chauffage-ventilation

- Fonctionne à bas régime et sans bruit.

Moteur
- Moteur 2 vitesses standard et fonctionnant normalement à petite vitesse.

Collet de filtre
- Muni d'un filtre de qualité conçu pour fonctionner jour et nuit.
- Tiroir du filtre monté sur glissière pour faciliter l'accès.

Convecteur
- Conception unique permettant une variation du débit de l'eau et de la chaleur proportionnelle à la perte d'énergie, ce qui favorise une température constante en tout temps.
- Assure une qualité d'air bien supérieur à celle que procurent les appareils classiques à air pulsé.

Enveloppe
- L'isolation thermique et acoustique de l'enveloppe est un des nombreux avantages de l'appareil.
- La construction monocoque de l'enveloppe aide à éliminer les vibrations.
- L'appareil offre une grande souplesse d'installation.

1.2.3 Contrôle MP - 2001

Le contrôle MP 2001 est un contrôle électronique de haute technologie qui organise la gestion des diverses fonctions du système AIR 2001.

Les fonctions:

- Contrôle de la température interne de la chaudière pour la production d'eau chaude domestique.
- Analyse de la température de sortie du ventilateur.
- Analyse de la température ambiante de la résidence.
- Contrôle de la puissance de chauffage par le biais du circulateur.
- Motorisation du ventilateur à basse vitesse et à haute vitesse selon la demande.
- Contrôle du brûleur.
- Commande de la climatisation.
- Alimentation du volet motorisé d'air frais.
- Analyse du signal du thermostat.
- Limitation au minimum des écarts de température ambiante.

Section 2 Installation des composantes

2.1 Dimensionnement du système

Le système AIR 2001 n'est pas un système de chauffage conventionnel et une attention spéciale doit être portée lors du dimensionnement de chacune des composantes pour assurer un confort maximal.

2.1.1 Nombre de zones

Le système AIR 2001 peut contrôler un maximum de 2 zones de chauffage-climatisation. Le nombre de zone choisi dépend essentiellement des caractéristiques physiques du système de conduits d'air. Un système est considéré 1 zone lorsque tout l'air distribué à partir de 1 unité de chauffage-ventilation est évacué dans 1 réseau unique de distribution.

Dans la terminologie AIR 2001 le système est considéré 2 zones lorsque l'on utilise 2 unités de chauffage-ventilation pour distribuer l'air dans 2 réseaux de conduits d'air séparés. **Les conduites de retour peuvent être communes mais les conduites d'alimentation doivent être completement individuelles.**

Un réseau de distribution d'air zoné à l'aide de volets mus par des moteurs 24 VAC doit être, du point de vue du contrôle AIR 2001, considéré comme étant 1 zone. Dans ce cas, chacun des volets motorisés doit être contrôlé par son propre thermostat qui doit être indépendant du thermostat principal AIR 2001.

2.1.2 Volume d'air

Avec le système AIR 2001, les besoins en chauffage ne sont plus déterminés par la capacité de l'unité chauffante en BTU/HRE mais bien par le volume d'air qui doit être traité. Consulter le tableau 1.

Par exemple, une maison de 20 pieds par 40 pieds avec 2 étages de 8 pieds de haut représente 20 X 40 X 8 X 2 soit 12800 pieds cubes. Par le tableau 1 on détermine une unité de chauffage-ventilation FC-75.

Dans le cas de conduites ou la restriction est grande (plus de 0.28 " de colonnes d'eau de différence entre le bonnet de retour et d'alimentation), il est suggéré de choisir une unité chauffage-ventilation munie de l'option Haute Pression Statique (HPS). Le cas le plus fréquent qui requiert une haute pression statique est la situation ou il y a un serpentin de climatisation dans le système. L'option haute pression statique peut développer jusqu'a 0.48 " de colonnes d'eau entre les bonnets. D'ailleurs, si votre système est muni d'un serpentin de climatisation veuillez consulter la section 2.1.5 avant d'arrêter le choix de votre unité chauffage-ventilation.

Volume d'air à traiter (pieds cube)	Unité de chauffage-ventilation
13500 et moins	FC-75
13500 à 17000	FC-94
17000 à 20000	FC-113
20000 à 24000	FC-131

Dimensionnement de l'unité chauffage-ventilation
Tableau 1

2.1.3 Chauffage

Votre besoin en chauffage est déterminé par votre volume d'air à traiter comme expliqué à la section précédente. Dans l'exemple précédent, votre choix s'arrêterait sur une unité FC-75 pouvant vous donner une capacité maximale de 75000 Btu/Hre.

2.1.4 Eau chaude domestique

Le besoin en eau chaude domestique couplé avec les besoins en chauffage dejà déterminé plus haut servent pour déterminer le modèle de chaudière HMD requise. Veuillez consulter le tableau 2.

Par exemple, si la demande en eau domestique est 150 USGPH pour l'exemple précédent (unité FC-75) la chaudière requise est une HMD-146B.

Débit d'eau chaude requise à 115 F (USGPH)	Unité chauffage-ventilation			
	FC-75	FC-94	FC-113	FC-131
50	HMD-124B	HMD-124B	HMD-124B	HMD-135B
100	HMD-135B	HMD-135B	HMD-135B	HMD-146B
150	HMD-146B	HMD-146B	HMD-146B	HMD-163B
200	HMD-163B	HMD-163B	HMD-163B	HMD-179B
250	HMD-208B	HMD-208B	HMD-208B	HMD-208B
300	HMD-235B	HMD-235B	HMD-235B	HMD-235B

Dimensionnement de la chaudière
Tableau 2

2.1.5 Climatisation

Si le système est pourvu d'un serpentin de climatisation, il faut prévoir un débit d'air de 400 CFM par Tonne de climatisation (1 tonne = 12000 Btu/Hre) pour l'unité chauffage-ventilation. Il faut donc consulter le tableau 3 pour la sélection de l'équipement. La sélection est faite en choisissant l'unité de chauffage-ventilation la plus grosse entre la table 1 et la table 3. De plus, il faut opter pour l'option haute pression statique (HPS).

Par exemple, dans la situation discutée précédemment, si le système est doté d'un serpentin de réfrigération de 2 tonnes, l'unité choisie selon la table 3 est un FC-94 HPS. La table 1 nous donnait une unité FC-75. On prend donc la plus grosse unité soit le FC-94 HPS.

Capacité de l'unité de réfrigération (Tonnes)	Unité Chauffage-ventilation
1/2	FC-75 HPS
1	FC-75 HPS
1-1/2	FC-75 HPS
2	FC-94 HPS
2-1/2	FC-113 HPS
3	FC-131 HPS

Dimensionnement de l'unité Chauffage-climatisation avec serpentin de climatisation.
Tableau 3

2.1.6 Air frais

Le besoin en air frais est tenu en considération lors de la sélection de l'unité de chauffage-ventilation. Le diamètre minimum du tuyau d'amenée d'air frais doit être de 5 pouces et le maximum de 6 pouces. Une prise d'air frais extérieur est disponible en option. De plus, un volet motorisé contrôlant l'admission d'air frais est aussi disponible en option. Le conduit d'air frais doit être raccordé au système sur le bonnet principal (plénum) de retour en amont de l'unité chauffage-ventilation.

2.1.7 Thermostat

Dans le concept du micro-processeur MP 2001, le thermostat commande ou termine la demande en chauffage ou en climatisation. Il est très important dans le montage électrique de s'assurer que le thermostat est compatible au contrôle MP-2001.

2.1.7.1 Chauffage seulement

Tout les thermostats de chauffage à deux fils sont compatibles avec MP-2001. Mettre l'anticipateur du thermostat à la valeur maximum (LONGER CYCLE).

2.1.7.2 Chauffage - climatisation

Une attention très spéciale doit être porté aux thermostats combinés chauffage-climatisation, un mauvais branchement pouvant sérieusement endommager le contrôle MP-2001 ainsi que le thermostat lui-même.

Les thermostats utilisés doivent être des thermostats quatre fils en ayant soin d'enlever le cavalier s'il y a lieu. Veuillez consulter le tableau 4. Si vous avez des doutes sur la compatibilité de votre thermostat, contactez DETTSON.

	HONEYWELL	WHITE RODGERS	MP-2001
BORNE CHAUFFAGE	RH	RH ou 4	RH
BORNE CHAUFFAGE	W	W	W
BORNE CLIMATISATION	R	Rc	R
BORNE CLIMATISATION	Y	Y	Y
CAVALIER A ENLEVER	RH & R	RH & Rc	-

Bornes et fils des thermostats
Tableau 4

2.1.8 Filtration

L'unité de filtration comprise en équipement standard avec l'unité de chauffage-ventilation est un filtre "Papier" haute performance. Vous pouvez choisir en option un filtre électrostatique.

2.2 Réception

2.2.1 Etat de la réception

Inspectez soigneusement les composantes de votre AIR 2001 au moment de la réception afin de vous assurer qu'ils n'ont pas été endommagé au cours du transport. Toutes réclamations pour dommages ou matériel manquant doivent être faits à la compagnie de transport.

2.2.2 Composantes de l'expédition - AIR 2001

Voici la liste des pièces devant venir en équipement standard avec votre système AIR 2001.

- 1 chaudière HMD
- 1 unité chauffage-ventilation
- Boite d'accessoires comprenant :
    - 1 bruleur complet Dettson-Beckett AFG
    - 1 gicleur Delavan
    - 1 Valve de surpression 3/4 " - 30 psi
    - 1 valve de drainage 3/4 "
    - 1 manuel d'instruction de bruleur
    - 1 manuel d'instruction AIR 2001
    - 1 régulateur de tirage
    - 1 couvercle de bruleur
    - 1 contrôle électronique MP 2001
    - 1 circulateur avec brides 3/4 "
    - 2 soupapes anti-gravité
    - 1 valve de mélange 1/2 "
    - 1 réservoir d'expansion
    - 1 prise extérieure d'amenée d'air frais

2.3 Installation de la chaudière

2.3.1 Emplacement

Votre chaudière doit être installée le plus près d'un conduit d'évacuation et dans un endroit propre et sec. Les chaudières HMD ne sont pas approuvées pour installation sur plancher combustible.

2.3.2 Dégagements

Nous recommendons pour fins d'entretien et d'accessibilité les dégagements suivants. Ces dégagements sont plus grand que ceux exigés par l'ACNOR. Pour les dégagements officiels ACNOR, veuillez consulter la plaque signalétique de la chaudière.

Dessus : 24 pouces
Tuyau à fumée : 9 pouces
Premier coté : 36 pouces
Deuxième coté : 36 pouces
Avant : 48 pouces
Arrière : 36 pouces

2.3.3 Location du contrôle MP-2001

Recommandations

- 3 pieds de la chaudière HMD
- 5 pieds du réservoir de mazout
- 5 pieds du sol

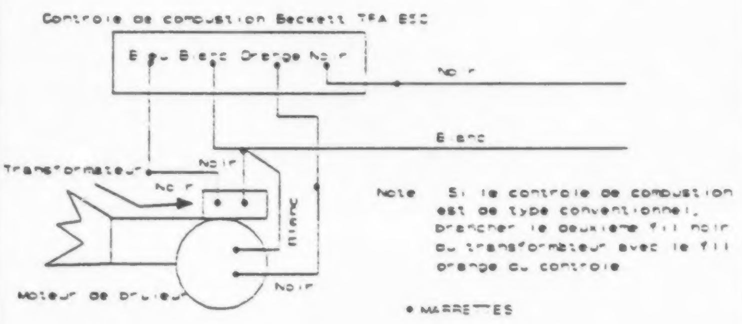
- Choisir un endroit:
  - Propre et sec
  - Bien éclairé
  - Facile d'accès.

2.3.4 Cablage et régulateurs

Les seuls raccordements électriques requis pour la chaudière HMD sont le raccordement au bruleur avec le conduit B-X fourni avec la chaudière et le raccordement entre la chaudière et le contrôle électronique MP 2001. Ceci est fait en utilisant un conduit B-X 2 conducteurs de jauge 14.

Tout l'appareillage interne à la chaudière est fait en usine et ne requiert aucune modification. Il est INTERDIT de modifier l'ajustement de l'aquastat haute-limite mécanique situé à l'endos du panneau amovible de contrôle de la chaudière. Une modification à ce contrôle annule la garantie et la certification ACNOR de la chaudière.

Pour le raccordement électrique entre la chaudière et le bruleur veuillez consulter la figure 1.



Note Si le controle de combustion est de type conventionnel, brancher le deuxieme fil noir du transformateur avec le fil orange du controle

BRANCHEMENT DU BRULEUR
FIGURE #1

2.3.5 Installation du réservoir à huile

L'installation du réservoir doit être conforme aux règlementations et codes locaux.

Nous recommendons que le bruleur soit installé avec un système à deux tubes. Toutefois, il peut être installé avec un système à un tube si la hauteur du fond du réservoir n'est pas plus de 8 pieds au dessous du niveau du bruleur. Le bruleur Beckett-Dettson livré avec l'unité est ajusté en usine pour un système à un tube. Ajouter l'orifice de dérivation pour un système à deux tubes (cet orifice est dans un sac sur la ligne à huile du bruleur).

Pour plus de renseignement consulter la brochure d'installation du bruleur fournie avec votre système AIR 2001.

2.3.6 Evacuation des gaz de combustion

2.3.6.1 Tirage - Cheminée

Le tirage recommendé pour les modèles HMD est de 0.035 pouces de colonne d'eau. En aucun cas, le tirage ne doit être inférieur à 0.020 pouces de colonne d'eau.

2.3.6.2 Installation

L'emploi d'un registre de bloquage (damper) dans le tuyau de raccordement est prohibé.

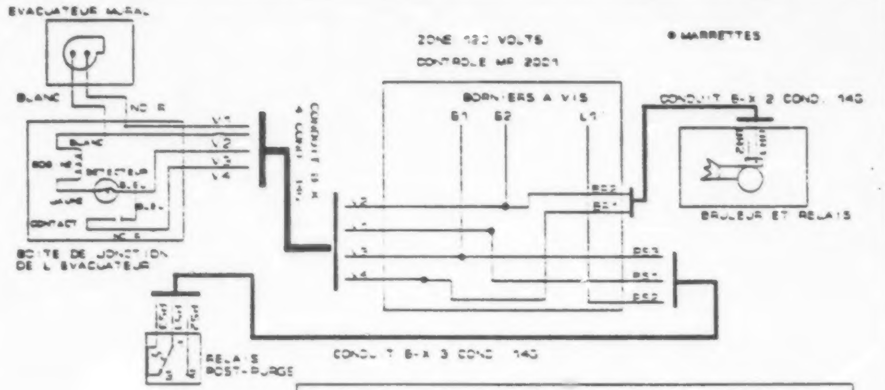
L'utilisation du régulateur barométrique de tirage est obligatoire avec les fournaises HMD et l'omission de celui-ci est une condition suffisante pour annuler la garantie de l'unité.

Consulter le code CSA B139 pour plus de renseignements.

AVIS : Il est à noter que lors de l'utilisation d'une chaudière à eau chaude, il se peut qu'il y ait formation de condensation au niveau d'une cheminée à 3 faces extérieures. Si tel est le cas, l'installation d'un système d'évacuation mural SWV-1M-2S serait requis.

2.3.6.3 Evacuation murale

Les chaudières HMD sont approuvés pour installation avec système d'évacuation mural SWV-1M-2S de DETTSON. Veuillez consulter la figure 2 pour le diagramme schématique de branchement du système d'évacuation mural. Nous vous suggérons fortement de suivre à la lettre ce schéma car de cette facon toutes les connections se font à l'intérieur du contrôle MP 2001. Il faut un conduit B-X 4 conducteurs de jauge 14 entre la boite de jonction de l'évacuateur et le contrôle MP 2001 et un conduit B-X 3 conducteurs de jauge 14 entre le relais post-purge sur le tuyau à fumée et le contrôle MP 2001. Si vous installez ce système, veuillez consulter le manuel d'instruction livré avec celui-ci.



BRANCHEMENT EVACUATEUR MURAL

FIGURE #2

2.3.7 Renseignements relatifs au bruleur

2.7.3.1 Renseignements généraux

Le bruleur n'est pas installé sur la chaudière. Ce bruleur est un bruleur Beckett-Dettson AFG-V1. Pour installer le bruleur sur la chaudière vous n'avez qu'à le fixer à la bride de soutien à l'aide des 4 écrous de vissage fournis avec l'unité. Assurez vous que le joint d'étanchéité est bien en place avant de visser le bruleur.

2.7.3.2 Gicleur

Le gicleur n'est pas installé sur le bruleur en usine. Lors de la pose du gicleur dans le bruleur, assurez vous de bien serrer celui-ci. Pour plus de renseignements consultez le manuel d'instruction du bruleur. Tout les gicleurs utilisés avec les fournaises HMD sont des Delavan avec un patron de flamme de type solide (B) d'un angle de 70 degrés. Tout autre gicleur annule la certification ACNOR.

2.7.3.3 Caractéristiques techniques

Veuillez consulter le tableau 5.

2.3.8 Air de combustion

Le bon fonctionnement de tout système de chauffage au mazout dépend d'une alimentation d'air adéquate et fonctionnelle. Si votre chaudière se trouve dans un endroit restreint, vous devrez faire deux ouvertures d'aération dans la pièce ou se trouve l'unité. Ces ouvertures doivent avoir chacune un pouce carré par 1000 BTU/HRE de puissance de l'appareil. Une des ouvertures doit être localisé près du plafond et l'autre près du plancher pour assurer une bonne circulation d'air.

Modele	Bruleur	Tête Rét.	Gicleur	Pres. (PSI)	Cap. (MBH)	Input (USGPH)
HMD-124B	Beckett AFG	V1	1.00-70B	100	124	1.00
HMD-135B	Beckett AFG	V1	1.10-70B	100	135	1.10
HMD-146B	Beckett AFG	V1	1.20-70B	100	146	1.20
HMD-163B	Beckett AFG	V1	1.35-70B	100	163	1.35
HMD-179B	Beckett AFG	V1	1.50-70B	100	179	1.50
HMD-208B	Beckett AFG	V1	1.75-70B	100	208	1.75
HMD-235B	Beckett AFG	V1	2.00-70B	100	235	2.00

Caractéristiques techniques de la chaudière HMD
Tableau 5

2.3.9 Plomberie

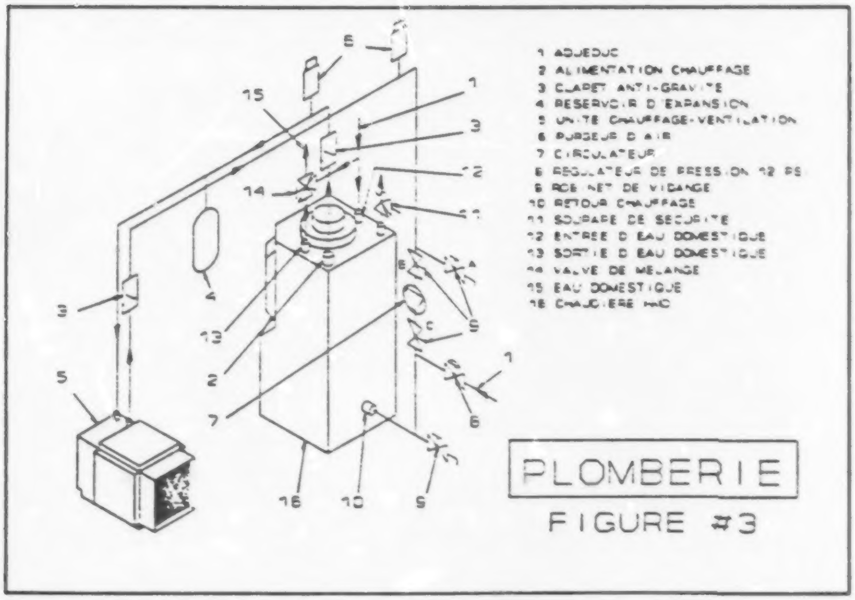
2.3.9.1 Introduction

Il est recommandé par le manufacturier que la tuyauterie reliant la chaudière au serpentin de l'unité chauffage-ventilation soit d'une grosseur de 3/4 pouce de diamètre pour minimiser les pertes de charges dans le circuit. Voir la figure no. 3.

La tuyauterie du circuit de l'eau domestique est d'une grosseur de 1/2 pouce de diamètre pour un raccordement facile aux équipements déjà existants.

2.3.9.2 Schématique

2.3.9.3 Composantes principales


1 AQUEDUC
2 ALIMENTATION CHAUFFAGE
3 CLAPET ANTI-GRAVITE
4 RESERVOIR D'EXPANSION
5 UNITE CHAUFFAGE-VENTILATION
6 PURGEUR D'AIR
7 CIRCULATEUR
8 REGULATEUR DE PRESSION 12 PS
9 ROBINET DE VIDANGE
10 RETOUR CHAUFFAGE
11 SOUPAPE DE SECURITE
12 ENTREE D'EAU DOMESTIQUE
13 SORTIE D'EAU DOMESTIQUE
14 VALVE DE MELANGE
15 EAU DOMESTIQUE
16 CHAUDIERE HMD
1
2
3
4
5
6
7
9
10
12
13
14
15
16
A
B
C

PLOMBERIE
FIGURE #3

- Circulateur: ajustement au maximum de sa vitesse.

- Clapet anti-retour. Dans le circuit de la tuyauterie nous retrouvons deux clapets anti-retour, l'un placé à la sortie de la chaudière et l'autre à la sortie du radiateur de l'unité de ventilation.

- Robinet de drainage. Pour un drainage d'air efficace du circuit d'eau, fermer le robinet 9-C, et ouvrir le robinet 9-A. Dans une telle situation, on s'assure que l'air est sorti complètement du circuit. Suite à cette manoeuvre, fermer le robinet 9-A et ouvrir le 9-C.

2.3.10 Régulateur de tirage

Un régulateur de tirage (fourni par Dettson) doit être installé sur le tuyau de raccordement entre la chaudière et la cheminée. Ceci est aussi vrai dans le cas des systèmes d'évacuations muraux SVV-1M-2S. Ce régulateur de tirage doit être facile d'accès. Consulter les instructions d'installation fournies avec celui-ci.

2.4 Installation de l'unité chauffage-ventilation

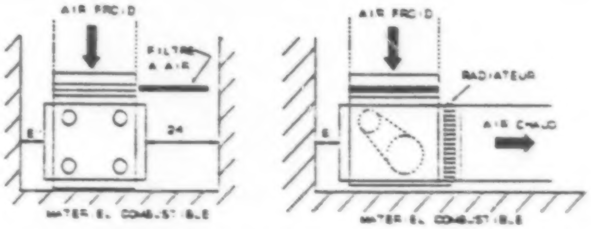
2.4.1 Emplacement

L'installation de l'unité de ventilation doit être dans un emplacement propre et sec, et dans la mesure du possible, éclairé. Un dégagement zéro est permis.

2.4.2 Orientation et accès

Même si aucun dégagement officiel n'est requis, il faut considérer un certain espace d'entretien pour l'unité de chauffage-ventilation.

La figure no. 4 démontre la position recommendée pour l'installation de l'unité de ventilation qui tient en considération l'espacement requis pour l'entretien du filtre à air et du moteur du ventila-teur. Assurez vous que la porte d'accès à l'unité est toujours du côté des poulies du moteur-ventilateur. Assurez-vous que l'unité de ventillation est installé solidement et que le ventilateur et le moteur sont bien alignés à l'horizontale. Utiliser un joint flexible pour fixer le plénum et l'unité de ventillation afin de réduire au minimum le bruit qui pourrait être transmis. Le montage des conduits de circulation d'air doit être fabriqué pour éviter au maximum la turbulence et la résistance d'air à l'intérieur du système de circulation. (Référence: spec. ASHRAE)



NOTES LA PORTE D ACCES DOIT ETRE DU MEME COTE QUE LA GLISSIERE DU FILTRE A AIR. DE PLUS, CETTE PORTE D ACCES DOIT ETRE DU COTE GAUCHE DU RADIATEUR SI ON REGARDE CELUI-CI PAR LE DEVANT EVIDEMMENT, TOUTE COMBINAISON RESPECTANT CES REGLES EST AUSSI VALABLE

ORIENTATION DE L UNITE CHAUFFAGE-VENTILATION

FIGURE #4

2.4.3 Cablage

Le seul cable électrique pour l'unité chauffage-ventilation est un conduit B-X 3 conducteur de jauge 14 entre l'unité et le contrôle MP-2001.

2.4.4 Renseignements relatifs au ventilateur

Les deux tableaux suivants donnent toutes les informations techniques concernant l'unité chauffage-ventilation.

Modèle	Capacité maximum Btu/Hre	CFM		Pression statique (" W.C.)	Delta T (F)
		Basse vit.	Haute vit.		
FC-75	74800	540	800	0.20	85
FC-75-HPS	74800	540	800	0.40	85
FC-94	93500	670	1000	0.20	85
FC-94-HPS	93500	670	1000	0.40	85
FC-113	112200	800	1200	0.20	85
FC-113-HPS	112200	800	1200	0.40	85
FC-131	130900	940	1400	0.20	85

Capacité de l'unité Chauffage-ventilation
Tableau 6

Modèle	Moteur (H.P.)	Poulie moteur (pouces)	Poulie ventil. (pouces)
FC-75	1/3	3-1/2	7
FC-75-HPS	1/3	3-1/2	7
FC-94	1/3	3-1/2	7
FC-94-HPS	1/2	3-1/2	6
FC-113	1/2	3-1/2	6
FC-113-HPS	3/4	3-1/2	5
FC-131	3/4	3-1/2	5

Description moteurs-poulies de l'unité chauffage-ventilation
Tableau 7

2.5 Installation du contrôle MP-2001

2.5.1 Cablage haute tension

Voir les figures suivantes selon les caractétistiques de votre système.

Figure no. 5 : 1 zone avec cheminée
Figure no. 6 : 1 zone avec évacuateur mural
Figure no. 7 : 2 zones avec cheminée
Figure no. 8 : 2 zones avec évacuateur mural

2.5.2 Schématique de la carte de puissance

Les branchements des conduits B-X à l'intérieur du contrôle MP-2001 sont comme à la figure #9.

2.5.3 Cablage basse tension

2.5.3.1 Equipement à cabler

Consultez la figure no. 10.

- Thermostat de chauffage
- Thermostat de climatisation (optionnel)
- Sonde de température de la chaudière
- Sonde de température d'air chaud dans le plénum
- Sonde de température ambiante
- Thermostat
- Signal du Compresseur pour l'air climatisé (optionnel)
- Signal du volet motorisé d'air frais (optionnel).

2.5.3.2 Localisation obligatoire

De par le code électrique canadien les tensions différentes doivent être séparé dans une boîte électrique. Il est donc obligatoire que les équipements basse tension ne soient en aucun temps dans le même compartiment que l'équipement à haute tension.

2.5.3.3 Emplacement des sondes

* Température de la chaudière

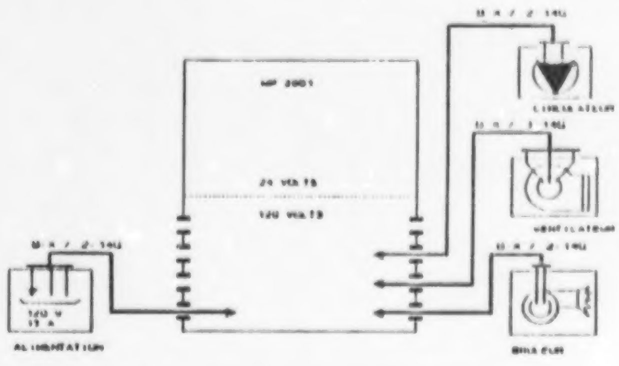
La localisation de la sonde est à l'arrière de la chaudière dans un puit de 9/32 " fourni par Dettson. Cette sonde épouse de près la forme du puit et doit être inséré avec précaution jusqu'au fond de ce puit.

* Température de sortie du plénum

Cette sonde doit être localisé à environ 2 pieds au dessus du serpentin de l'unité chauffage-ventilation dans le plénum d'air chaud. Il est important d'utiliser le support de sonde fourni par DETTSON.

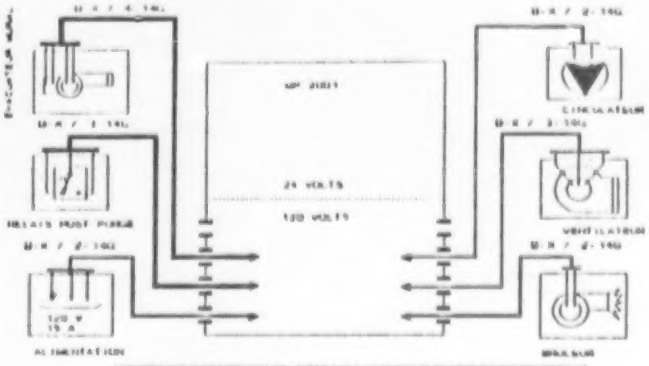
* Température ambiante

Cette sonde doit être localisé près d'une bouche de retour d'air à proximité du thermostat d'ambiance. L'installation doit être murale. Voir la figure no. 11.


B-R / 2-14G
CIRCULATEUR
B-R / 3-14G
VENTILATEUR
B-R / 2-14G
BRULEUR
MP 2001
24 VOLTS
120 VOLTS
B-R / 2-14G
120 V
15 A
ALIMENTATION

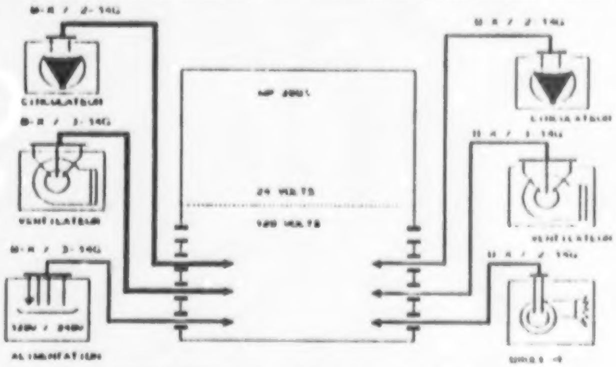
1 ZONE AVEC CHEMINEE

FIGURE #5


B-R / 4-14G
EVACUATEUR MURAL
B-R / 3-14G
RELAIS POST PURGE
B-R / 2-14G
120 V
15 A
ALIMENTATION
MP 2001
24 VOLTS
120 VOLTS
B-R / 2-14G
CIRCULATEUR
B-R / 3-14G
VENTILATEUR
B-R / 2-14G
BRULEUR

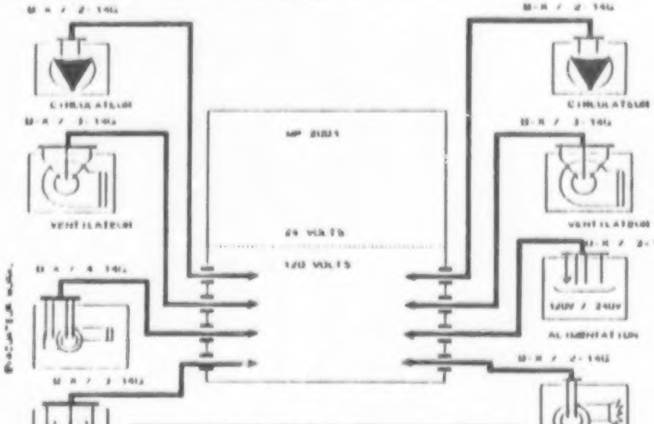
1 ZONE AVEC EVACUATEUR MURAL

FIGURE #6


B-R / 2-14G
CIRCULATEUR
B-R / 3-14G
VENTILATEUR
B-R / 3-14G
120V / 240V
ALIMENTATION
MP 2001
24 VOLTS
120 VOLTS
B-R / 2-14G
CIRCULATEUR
B-R / 3-14G
VENTILATEUR
B-R / 2-14G
BRULEUR

2 ZONES AVEC CHEMINEE

FIGURE #7


B-R / 2-14G
CIRCULATEUR
B-R / 3-14G
VENTILATEUR
B-R / 4-14G
EVACUATEUR MURAL
B-R / 3-14G
RELAIS POST PURGE
MP 2001
24 VOLTS
120 VOLTS
B-R / 2-14G
CIRCULATEUR
B-R / 3-14G
VENTILATEUR
B-R / 2-14G
120V / 240V
ALIMENTATION
B-R / 2-14G
BRULEUR

2 ZONES AVEC EVACUATEUR

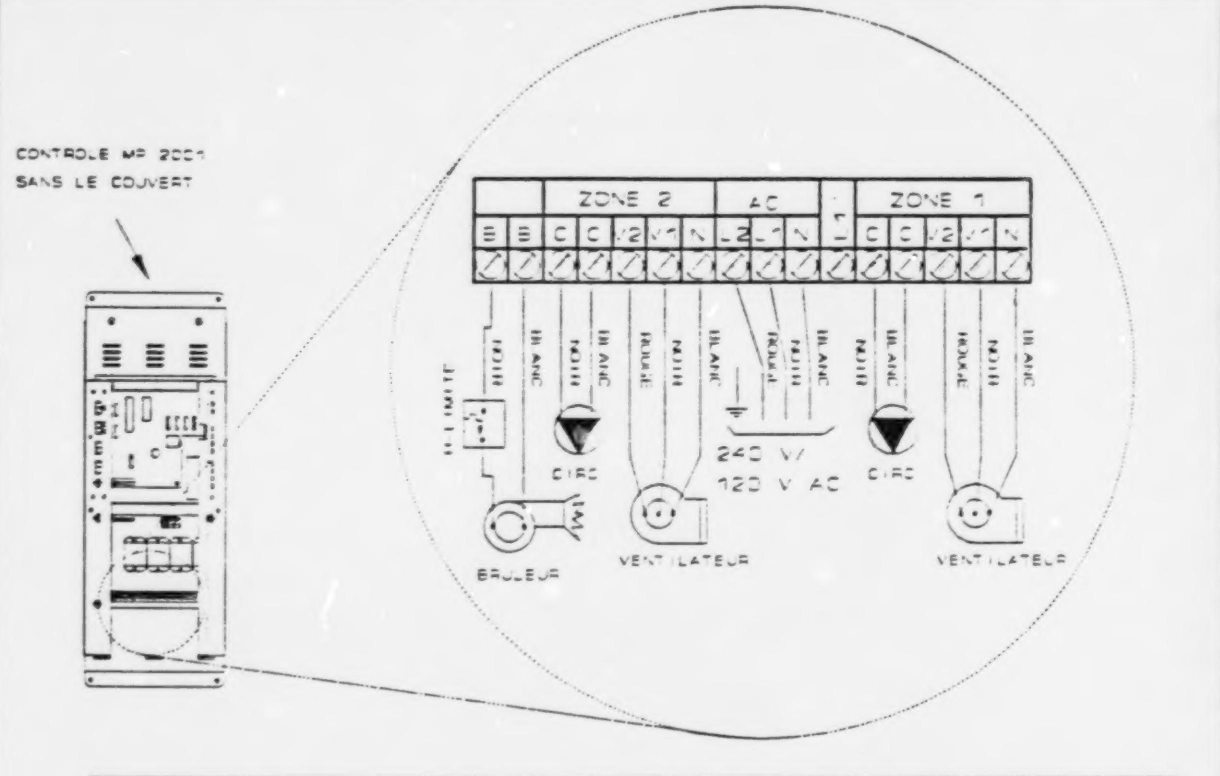
FIGURE #8

2.5.3.4 Thermostat

Consulter la section 2.1.7 pour vérifier la compatibilité de votre thermostat avec le controle MP2001. Il est important de brancher les fils du thermostat aux bornes correspondantes à la zone utilisé.

Zone 1 : Bornes chauffage : W1 et RH1
Bornes climatisation : R1 et Y1

Zone 2 : Bornes chauffage : W2 et RH2
Bornes climatisation : R2 et Y2


CONTROLE MP 2001
SANS LE COUVERT
ZONE 2
AC
ZONE 1
B
B
C
C
V2
V1
N
L2
L1
N
L
C
C
V2
V1
N
LIMITE
NOIR
BLANC
NOIR
BLANC
ROUGE
NOIR
BLANC
ROUGE
NOIR
BLANC
NOIR
BLANC
ROUGE
NOIR
BLANC
CIRC
240 V/
120 V AC
CIRC
BRULEUR
VENTILATEUR
VENTILATEUR

BRANCHEMENT 120 VOLTS SUR LA CARTE DE PUISSANCE

FIGURE #9

2.5.3.5 Compresseur de climatisation

Le contrôle électronique MP2001 a été concu pour actionner le compresseur de l'unité de climatisation par l'entremise d'un signal 24 volts AC lorsqu'il y a demande de climatisation.

Les bornes de connection du compresseur sont identifiés "COIL" sur le bornier de raccordement MP2001.

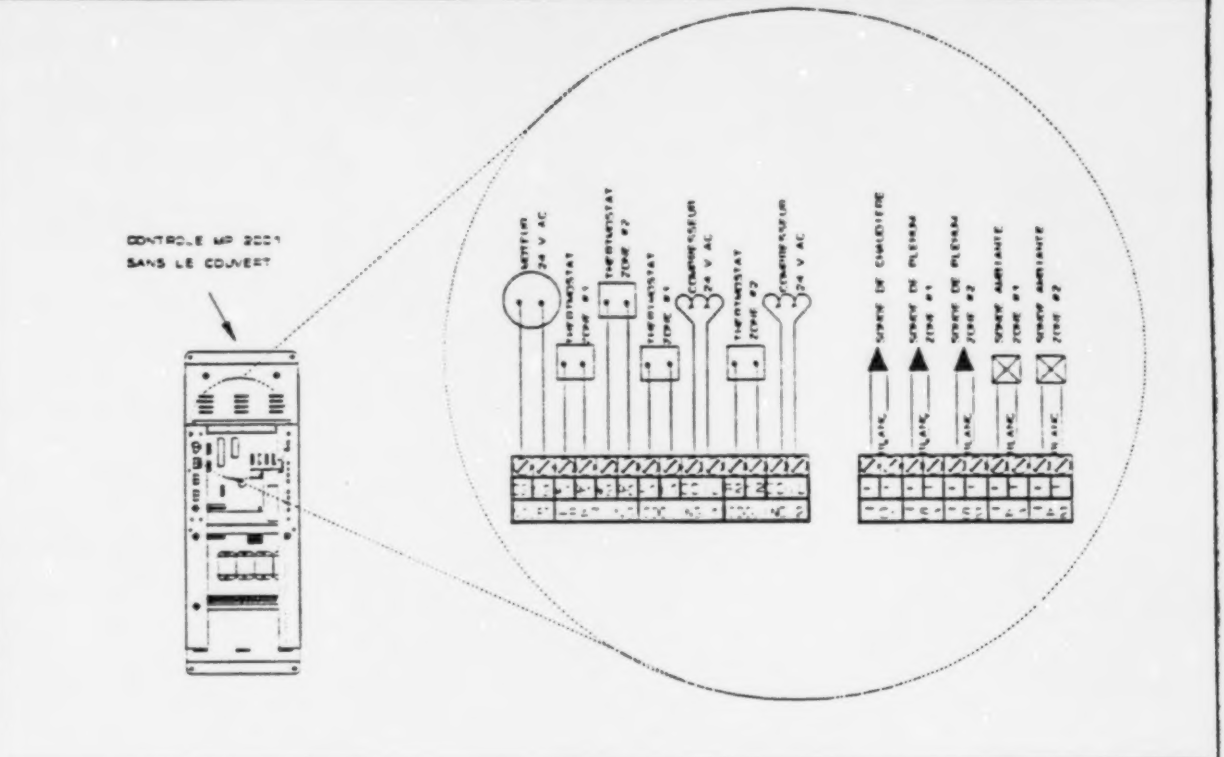
2.5.3.6 Volet motorisé

Le contrôle électronique peut actionner un volet motorisé (acheté en option) qui ouvre et ferme le conduit d'air frais provenant de l'extérieur. L'alimentation du volet motorisé sur le contrôle MP2001 est identifié par D2 et V2.

2.5.3.7 Circuit de secours

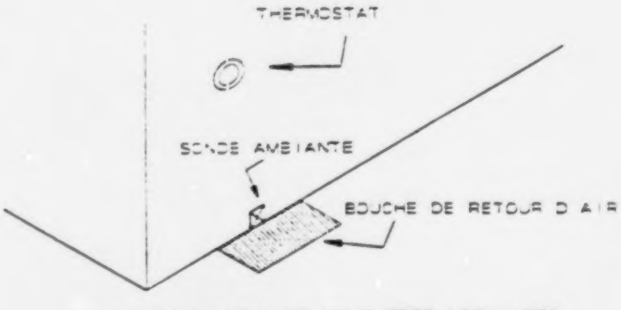
Il est possible d'installer sur le système un thermostat de secours qui, advenant une panne électronique au niveau du micro-processeur du contrôle permet de fournir du chauffage par le biais du bruleur, du ventilateur haute vitesse et du circulateur. Pour utiliser le système de secours, brancher tout simplement un thermostat sur les bornes SEC1 et COM du bornier de secours. La localisation de ce bornier est montré à la figure no. 12. Par exemple, si vous installez un thermostat de secours de cette facon et que vous ajustez ce thermostat à 60 degrés F vous aurez la protection décrite au paragraphe suivant.

Advenant un cas, très rare, de bris sur une des composantes électroniques résultant en une panne de chauffage, la température ambiante dans la maison va baisser graduellement jusqu'a ce qu'elle tombe sous 60 degrés F. A ce moment la, le circuit de secours prend le contrôle du système et démarre le bruleur, le ventilateur haute vitesse et le circulateur de facon a conserver une température au dessus de 60 degrés F.


CONTROLE MP 2001
SANS LE COUVERT
24 V AC
THERMOSTAT ZONE #1
THERMOSTAT ZONE #2
THERMOSTAT ZONE #1
COMPRESSEUR 24 V AC
THERMOSTAT ZONE #2
COMPRESSEUR 24 V AC
SONDE DE CHAUDIERE
SONDE DE PLENUM ZONE #1
SONDE DE PLENUM ZONE #2
SONDE AMBIANTE ZONE #1
SONDE AMBIANTE ZONE #2

BRANCHEMENT BASSE TENSION SUR LA CARTE DE CONTROLE

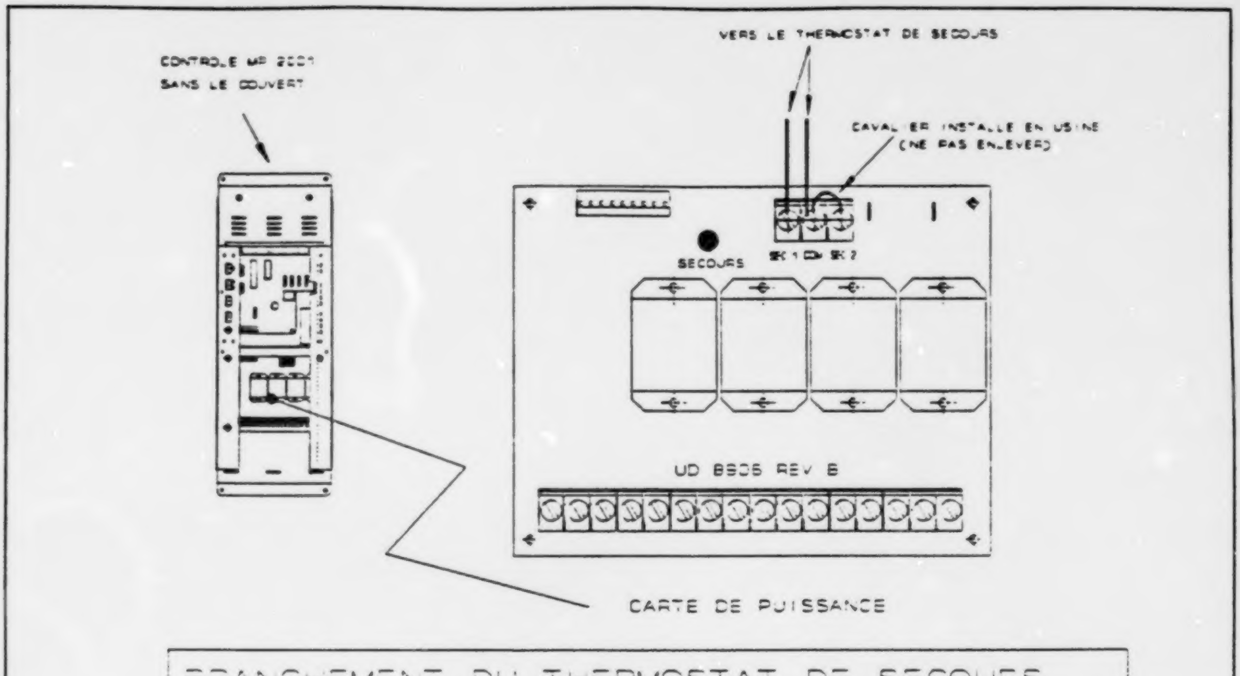
FIGURE #10


THERMOSTAT
SONDE AMBIANTE
BOUCHE DE RETOUR D AIR

LA SONDE AMBIANTE DOIT ETRE LOCALISEE
AU DESSUS DE LA BOUCHE DE RETOUR D AIR
LA PLUS PROCHE DU THERMOSTAT

LOCALISATION DE LA SONDE AMBIANTE

FIGURE #11


CONTROLE MP 2001
SANS LE COUVERT
VERS LE THERMOSTAT DE SECOURS
CAVALIER INSTALLE EN USINE
(NE PAS ENLEVER)
SECOURS
SK 1 COM SK 2
UD 8505 REV B
CARTE DE PUISSANCE

BRANCHEMENT DU THERMOSTAT DE SECOURS

FIGURE #12

Le circuit de secours est une protection simple, économique et fiable pour éviter les risques de gel dans la maison. Typiquement, le thermostat de secours est localisé à proximité du contrôle MP2001. Le voyant "SECOURS" (figure 13) clignote lorsque le système est en mode de secours. De plus, lors du fonction en mode secours le bruleur est interrompu par le biais de l'aquastat mécanique haute-limite de la chaudière.

IMPORTANT : Si vous installez un thermostat de secours, assurez-vous de le régler au moins 10 degrés F au-dessous de la température de votre thermostat principal.

[redacted]

Section 3 Mise en marche

3.1 Combustible

Utiliser uniquement du mazout # 2. Ne jamais utiliser du mazout plus lourd, de l'essence, de l'huile à moteur ou tout autre type de combustible.

3.2 Démarrage du bruleur

Pour simplifier les tests de démarrage du bruleur, mettez le(s) thermostat(s) en position satisfait avec le sélecteur de saison à HIVER. A ce stade ci vous pouvez laisser les interrupteurs de zones à OFF. Préparez vos instruments de mesures qui sont : manomètre incliné pour la lecture du tirage, pompe pour le test de fumée, analyseur de produits de combustion, thermomètre ou thermocouple pour tuyau à fumée et voltmètre digital.

Pour mettre le système, et le bruleur, en marche vous n'avez qu'à mettre le courant sur le circuit d'alimentation du contrôle MP 2001.

3.2.1 Tests de combustion

3.2.1.1 Test de tirage de cheminée

Laisser la cheminée se réchauffer pendant environ 5 minutes et prendre le tirage de cheminée à mi-chemin entre la sortie de la chaudière et le régulateur de tirage. La lecture devrait être de 0.035 " de colonne d'eau. Ceci est aussi vrai dans le cas des évacuateurs muraux.

3.2.1.2 Test de fumée

Il est important de vérifier le tirage avant de faire ce test car le tirage de la cheminée influe directement sur le test de fumée. Prendre le test de fumée qui devrait se situer entre 0 et 1 sur l'échelle Bacharrach. Ajuster le bruleur au besoin. Le guide d'ajustement initial du bruleur se trouve au tableau 8 plus bas. La position d'assemblage de gicleur est la position de ce qui est communément appelé le "drawer assembly". Voir le manuel d'instruction du bruleur pour plus de détails. Veuillez aussi noter que la pression de la pompe à huile du bruleur est de 100 psi pour tout les modèles de chaudière HMD. Prendre en note que sur les modèle HMD-124B et HMD-135B le bruleur doit être muni d'un déflecteur de bas régime (low firing rate baffle). Consulter le manuel d'instruction du bruleur à ce sujet.

Les ajustements du tableau 8 ne sont qu'un point de départ et doivent être obligatoirement être vérifiés aux instruments.

Modèle	Capacité (MBH)	Ajustement primaire	Ajustement secondaire	Assembl. gicleur
HMD-124B	124	0	5.5	0
HMD-135B	135	1	4	0
HMD-146B	146	1	4	1
HMD-163B	163	2	5.5	2
HMD-179B	179	2	5	3
HMD-208B	208	2	7	4
HMD-235B	235	5	5	4

Ajustements initiaux du bruleur Beckett-Dettson
Tableau 8

3.2.1.3 Test de température

La température des gaz à fumée à 18 " en aval de la sortie de la chaudière doit être inférieure à 575 degrés F.

3.2.1.4 Test de CO2

Analyser les produits de combustion. Le pourcentage de CO2 devrait se situer entre 12.5 et 13.5. Habituellement une lecture inférieure à 12.5 indique un trop grand excès d'air.

3.2.2 Redémarrage après une panne d'allumage

Si le relais de bruleur tombe en réarmement manuel ("reset") essayez de le redémarrer en pesant une fois sur le bouton rouge de réarmement du bruleur. Si après cette tentative, le bruleur ne démarre toujours pas, vérifiez les points suivants.

- Vérifier le niveau de mazout dans le réservoir.
- Vérifier si la soupape d'admission d'huile est bien ouverte.
- Vérifier si le filtre à huile n'est pas obstrué.
- Vérifier les fusibles de l'alimentation électrique principale.
- Vérifier les électrodes du bruleur. Pour ceci consulter le manuel du bruleur.
- Vérifier s'il y a de l'air dans le conduit d'admission d'huile du bruleur.
- Vérifier si l'ajustement du bruleur est correct.

Si après avoir suivi toutes ces étapes et avoir appuyé une dernière fois sur le bouton rouge du bruleur, ce dernier refuse toujours de démarrer, appelez votre technicien de chauffage. N'essayez jamais de remettre en marche le bruleur s'il y a un excès de mazout ou de vapeur de mazout dans la chambre à combustion.

3.2.4 Vérification du point de consigne

3.2.3.1 Ajustement du point de consigne

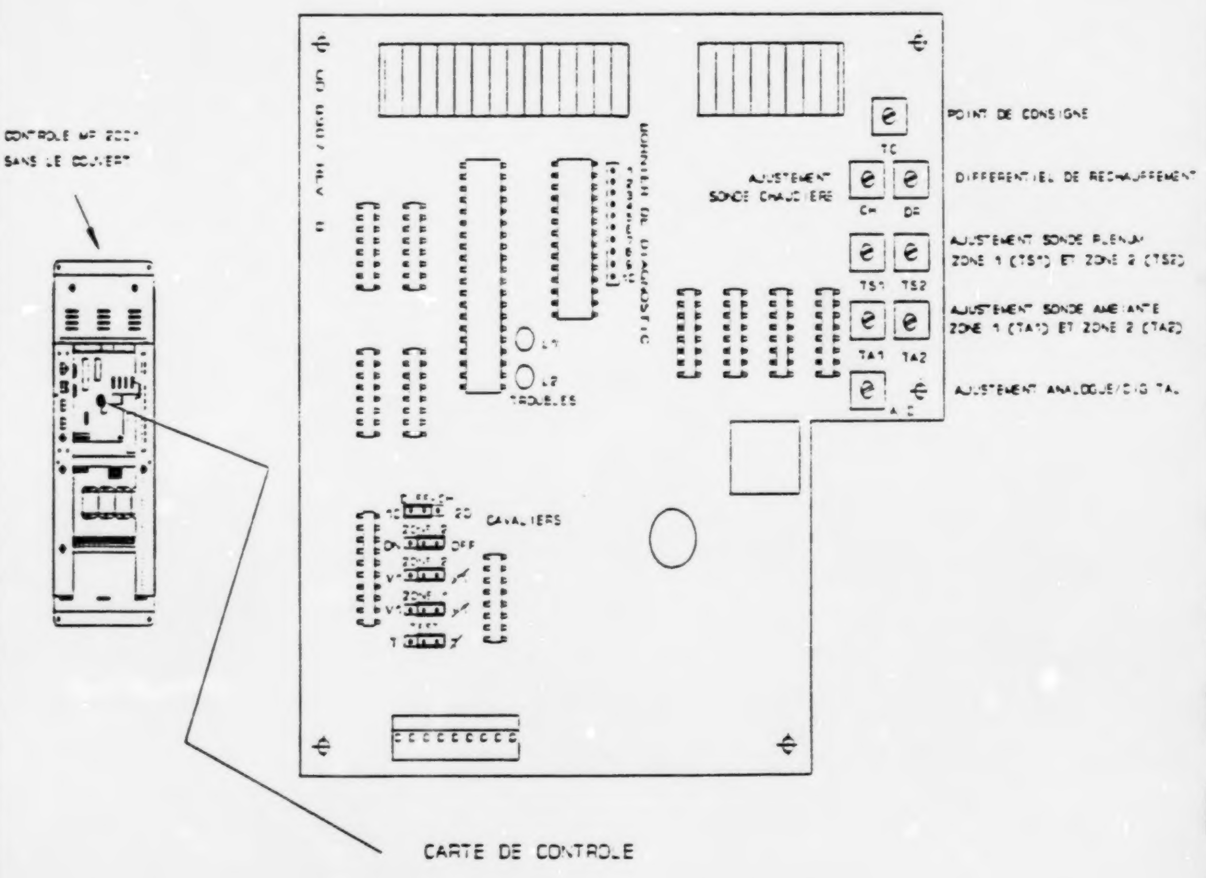
Le point de consigne de la chaudière (température de départ et arrêt) peut être ajusté avec le potentiomètre marqué TC sur la carte basse tension dans le contrôle MP 2001. Voir figure 13 pour un schéma de la localisation de cet ajustement. Le point d'ajustement varie entre 160 et 190 degrés F et représente le point de départ du bruleur lorsque la température dans la chaudière descend.

3.2.3.2 Différentiel

Le différentiel du point de consigne peut être de 10 ou 20 degrés F selon la position du cavalier #1 sur la carte basse tension du contrôle MP 2001. Voir la figure 13 pour un schéma de la localisation de ce cavalier. Le différentiel est ajouté au point de consigne et représente le point d'arrêt du bruleur lorsque la température de la chaudière monte. Par exemple, si le point de consigne est ajusté à 170 degrés F avec un différentiel de 20 degrés F, le bruleur va démarrer lorsque la température va descendre sous 170 degrés F et arrêter lorsque cette température va dépasser 190 degrés F.

3.2.3.3 Ajustement suggéré

L'ajustement suggéré est un point de consigne à 175 degrés F avec un différentiel de 10 degrés Fahrenheit.



CONTROLE MP 2001
SANS LE COUVERT
POINT DE CONSIGNE
TC
AJUSTEMENT SONDE CHAUDIERE
DIFFERENTIEL DE RECHAUFFEMENT
CH
DF
AJUSTEMENT SONDE PLENUM ZONE 1 (TS1) ET ZONE 2 (TS2)
TS1
TS2
AJUSTEMENT SONDE AMBIANTE ZONE 1 (TA1) ET ZONE 2 (TA2)
TA1
TA2
AJUSTEMENT ANALOGUE/DIGITAL
A D
L1
L2
TROUBLES
CAVALIERS
10
20
ON
OFF
V
T
CARTE DE CONTROLE

LOCALISATION DES COMPOSANTES PRINCIPALES - CARTE DE CONTROLE

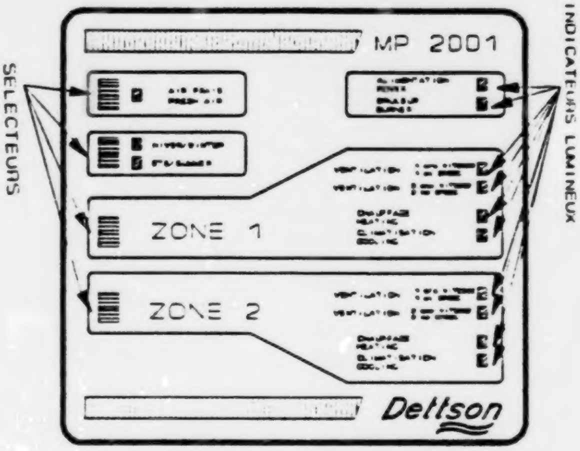
FIGURE #13

3.2.3.4 Haute limite mécanique

La chaudière est munie d'un aquastat haute-limite mécanique indépendant du contrôle MP 2001. Une modification à ce contrôle annule la garantie et la certification ACNOR de la chaudière.

3.3 Sélecteurs

La prochaine section explique les différentes fonctions des sélecteurs accessibles a l'utilisateur. Voir la figure no. 14 pour la localisation de ces sélecteurs.



PANNEAU DE FACADE - CONTROLE MP 2001

FIGURE #14

3.3.1 Air frais

Ce sélecteur est situé en haut à gauche sur la facade du contrôle MP2001. Lorsque ce sélecteur est en position fermée (On), MP 2001 contrôle volet motorisé (ouverture et fermeture) installé en option. Si ce volet n'est pas installé, ce sélecteur n'a aucune fonction.

3.3.2 Hiver-été

Situé sous le selecteur d'air frais, ce sélecteur en position HIVER permet au contrôle de fonctionner en mode chauffage. Inversement, la position ETE commande un mode climatisation. Lorsqu'un thermostat combiné chauffage-climatisation est utilisé, le choix du mode est fait automatiquement par le thermostat lorsque le sélecteur du contrôle MP2001 est en position HIVER. Dans un tel cas, la position ETE ne permet que le fonctionnement qu'en mode climatisation.

3.3.3 Zone 1 et Zone 2

Situés sous le sélecteur "Hiver-été", ces sélecteurs en position fermés (On) permettent le contrôle par l'entremise du MP 2001 des fonctions des zones 1 et 2.

3.4 Démarrage en mode chauffage

La section suivante vous indique les position de sélecteurs, thetmostat et cavaliers pour un démarrage en mode chauffage. Si vous démarrez le système en mode climatisation, veuillez aller directement à la section 3.5 .

3.4.1 Position des sélecteurs

* 1 zone
- Sélecteur d'air frais en position fermé s'il y a lieu (Option).
- Sélecteur HIVER-ETE en position HIVER
- Sélecteur ZONE 1 fermé (On)
- Sélecteur ZONE 2 ouvert (Off)

* 2 zones
- Sélecteur d'air frais en position fermé s'il y a lieu (Option).
- Sélecteur HIVER-ETE en position HIVER
- Sélecteur ZONE 1 fermé (On)
- Sélecteur ZONE 2 fermé (On)

3.4.2 Position des cavaliers

Les cavaliers (jumpers) de la carte électronique du contrôle MP 2001 doivent être dans les bonnes position pour un fonctionnement normal du système. Pour la localisation de ces cavaliers veuillez consulter la figure no. 13.

Cavalier #1 Différentiel du point de consigne

Ce cavalier a été discuté en section 3.2.3.2. Il est au choix de l'utilisateur soit 10 ou 20 degrés Fahrenheit.

Cavalier #2 Nombre de zone

Si ce cavalier est à droite le contrôle possède 1 zone et s'il est à gauche, MP2001 contrôle 2 zones.

Cavalier #3 Zone 2 - Climatisation

Ce cavalier permet de contrôler l'état du ventilateur basse vitesse de la zone 2 lorsque le contrôle est en mode climatisation hors cycle. Ce cavalier à droite signifie qu'en mode climatisation le ventilateur sera à l'arrêt hors cycle et en haute vitesse sur demande de thermostat. Si le cavalier est à gauche le ventilateur sera en basse vitesse hors cycle et en haute vitesse sur demande de thermostat. Ce cavalier permet de choisir ou non une circulation continu pour la zone 2 en mode climatisation.

Cavalier #4 Zone 1 - Climatisation

Ce cavalier a la même fonction que le cavalier #3 mais pour la zone 1.

Cavalier #5 Test

Ce cavalier permet d'augmenter la vitesse d'éxécution du contrôle MP2001 lors de test sur celui-ci. Ce cavalier doit toujours être à droite lors du fonctionnement du contrôle MP2001. Dans ce mode normal l'indicateur lumineux L1 (voir figure 14) allumera brievement à toutes les 60 secondes. Dans le mode test (cavalier à gauche), ce voyant allumera à toutes les 5 secondes.

3.4.3 Etat du thermostat

Mettre le thermostat en demande de chauffage. Si le thermostat possède un interrupteur chauffage-climatisation, celui-ci doit être en tout temps sur la position **chauffage**. Le système AIR 2001 est maintenant en marche et devrait fonctionner normalement.

3.5 Démarrage en mode climatisation

Si vous désirez démarrer le système en mode climatisation, la seul différence avec la section 3.4 est que le sélecteur "Hiver-été" doit être en position ETE.

Evidemment le thermostat devra être mis en demande de climatisation. Si le thermostat possède un interrupteur AUTO, celui-ci doit être en tout temps **sur la position AUTO**. Le système AIR 2001 est maintenant en marche et devrait fonctionner normalement.

Section 4 Opération

4.1 Voyants lumineux MP 2001

Dans les prochains paragraphes, vous trouverez la description des fonctions ainsi que la localisation des différents voyants lumineux se trouvant sur le contrôle MP 2001. Veuillez s.v.p. consulter la figure 14 qui est un schéma du panneau de facade du contrôle MP 2001.

4.1.1 Alimentation

Ce voyant est situé en haut à droite sur le panneau de contrôle. Une lumière verte s'allume lorsque l'alimentation principale 120 V ou 240 V est présente sur le contrôle. Un voyant vert signifie donc que le contrôle MP 2001 est énergisé.

4.1.2 Bruleur

Ce voyant est situé tout juste en bas du voyant d'alimentation et est de couleur jaune. Cette lumière s'allume lorsque le contrôle MP 2001 envoie un signal de fonctionnement au bruleur. Si le voyant jaune est allumé et que le bruleur ne fonctionne pas, cela signifie que le bruleur a été coupé par l'aquastat haute-limite mécanique interne de la chaudière. Un tel fonctionnement est anormal et signifie probablement un désajustement de la calibration de la sonde de chaudière. Consulter la section 6.6.2.2.

4.1.3 Zone 1

4.1.3.1 Ventilateur basse vitesse

Ce voyant vert est situé sous le voyant lumineux de bruleur et s'allume lorsque le ventilateur de la zone 1 fonctionne en basse vitesse.

4.1.3.2 Ventilateur haute vitesse

Ce voyant vert est situé sous le voyant lumineux de ventilateur basse vitesse et s'allume lorsque le ventilateur de la zone 1 fonctionne en haute vitesse.

4.1.3.3 Chauffage

Ce voyant rouge est situé sous le voyant lumineux de ventilateur haute vitesse et s'allume lorsque le circulateur de la chaudière est en fonction. Veuillez noter que le fonctionnement normal du système AIR 2001 nécessite une modulation presque constante du niveau de chauffage et que ce voyant rouge s'allume seulement lorsque le circulateur est effectivement en marche. Par exemple, si le contrôle décide que le cycle de circulation est de 5 secondes, le voyant lumineux sera allumé 5 secondes et éteint 55 secondes sur un temps standard de 1 minute. Veuillez noter que le contrôle prend une décision sur la durée de circulation à toute les minutes. Donc le temps de circulation est en constant changement.

4.1.3.4 Climatisation

Ce voyant jaune est situé sous le voyant lumineux de chauffage et ne sert que dans le cas ou le système est muni de l'option climatisation. Dans un tel cas, le voyant jaune s'allume lorsqu'il y a une demande de climatisation uniquement.

4.1.4 Zone 2

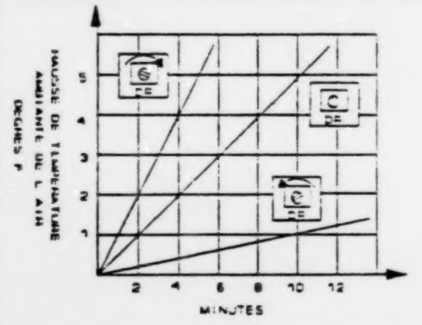
Si votre système est muni d'une option 2 zones, les voyants lumineux de la deuxième zone sous situés sous les voyants de la zone 1 et ont les mêmes caractéristiques et fonctions que ceux de la zone 1. Voir la figure 14.

4.2 Différentiel de réchauffement

Le seul ajustement requis par l'utilisateur, à part celui de la température de la chaudière, est l'ajustement du différentiel de réchauffement.

4.2.1 Concept

Le différentiel de réchauffement est le taux d'augmentation de la température ambiante recherché par le contrôle MP2001. Dans un système conventionnel de chauffage, le système démarre en pleine puissance sur demande de thermostat et arrete completement sur la fin de celui ci. Il en résulte des écarts de températures dans la maison et une sensation de surchauffe lorsque la fournaise fonctionne en pleine puissance. L'utilisateur n'a aucun contrôle sur le taux auquel la température ambiante va augmenter ou diminuer dans la maison.



DIFFERENTIEL DE RECHAUFFEMENT

FIGURE #15

Ceci est complètement différent avec un système AIR 2001 ou l'utilisateur peut décider du taux auquel la température va augmenter dans la maison lors d'une demande de thermostat. Ceci est fait à l'aide du potentiomètre DR sur la carte électronique (voir figure 13). La pente est exprimé en Degres F / minute et peut se situer entre 0.1 et 1.Voir la figure no 15. Un différentiel de réchauffement de 0.2 signifie que le contrôle MP 2001 va prendre action de facon à augmenter la température ambiante dans la maison de 0.2 degrés F par minutes lors d'une demande de thermostat.

Evidemment, le bénéfice majeur d'une telle action est d'éviter complètement les dépassements du point de consigne de thermostat (bouffées de chaleur) grâce à une modulation de la puissance de chauffage et une augmentation de la durée du cycle de chauffage en basse vitesse de ventilateur.

4.2.2 Ajustement recommandé

DETTSON considère que le meilleur confort est obtenu avec un différentiel de réchauffement minimal qui procure une augmentation de la température ambiante très graduelle et élimine les bouffées de chaleur. Une telle approche a aussi pour effet de diminuer l'écart entre la température minimale dans la pièce lorsque le thermostat commande le chauffage et la température maximale dans la pièce lorsque le thermostat est satisfait. Il est donc recommandé d'ajuster le potentiomètre DR au minimum (dévisser).

Dans le cas ou l'utilisateur veut un chauffage plus rapide, une augmentation (visser) du DR est souhaitable.

4.3 Vérifications d'opération normale

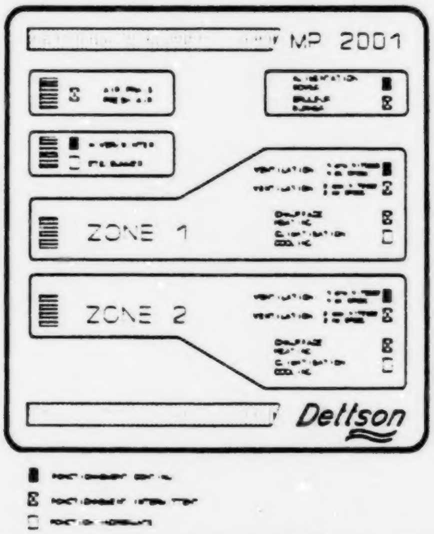
La section suivante permet à l'utilisateur de vérifier le fonctionnement normal de son système à l'aide de quelques points de repères facilement vérifiables.

4.3.1 Mode chauffage

Les vérifications suivantes doivent être faites lors du fonctionnement en mode chauffage.

4.3.1.1 Indicateurs lumineux

Consulter la section 4.1 et la figure no. 16.



CONTROLE MP 2001 - MODE CHAUFFAGE

FIGURE #16

4.3.1.2 Fonctionnement du circulateur

Le voyant lumineux rouge indiqué chauffage allumera selon la fréquence de circulation déterminé par le contrôle MP 2001.

4.3.1.3 Voyant lumineux L1

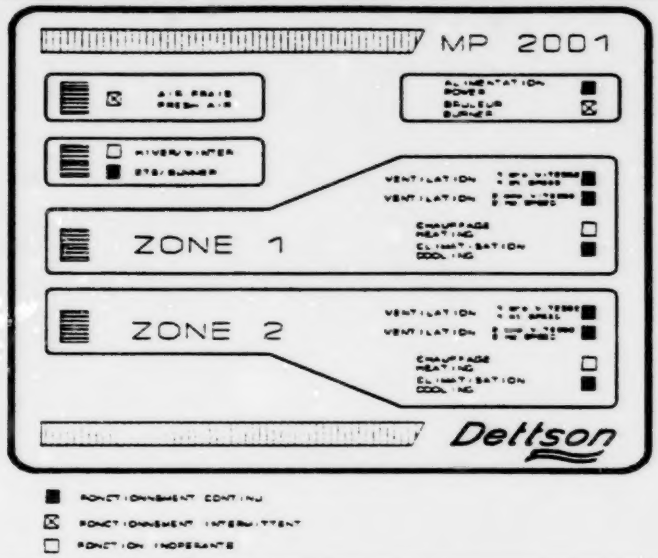
Sur la carte de contrôle, le voyant lumineux indiqué L1 (voir figure 13) devrait allumer brièvement 1 seconde à toutes les 60 secondes dans un fonctionnement normal. Ce délai de 60 secondes est le temps d'analyse du contrôle MP 2001.

4.3.1.4 Voyant lumineux "TROUBLES"

Sur la carte de contrôle, un voyant lumineux "TROUBLES" (voir figure 13) clignotant signifie un problème sur une des sondes du système. Si un tel cas se produit consulter la section 6 de ce manuel.

4.3.2 Mode climatisation

Lors d'une demande de climatisation, le ventilateur doit embarquer en haute vitesse et l'indicateur lumineux jaune "CLIMATISATION" doit allumer. Voir la figure no. 17. L'état du ventilateur hors cycle dans le mode climatisation dépend de la position des cavaliers #3 et #4 sur la carte de contrôle (consulter la Section 3.4.2).


MP 2001
AIR FRAIS
FRESH AIR
ALIMENTATION
POWER
BRULEUR
BURNER
HIVER/WINTER
ETE/SUMMER
VENTILATION
VENTILATION
CHAUFFAGE
HEATING
CLIMATISATION
COOLING
ZONE 1
VENTILATION
VENTILATION
CHAUFFAGE
HEATING
CLIMATISATION
COOLING
ZONE 2
Dettson
FONCTIONNEMENT CONTINU
FONCTIONNEMENT INTERMITTENT
FONCTION INOPERANTE

CONTROLE MP 2001 - MODE CLIMATISATION

FIGURE #17

Section 5 Entretien

5.1 Chaudière HMD

L'entretien recommandé pour la chaudière est détaillé dans les paragraphes suivants.

5.1.1 Bruleur

S'assurer que la soupape d'admission du mazout est fermée lorsque le bruleur n'est pas en service pour une longue période.

5.1.1.1 Moteur de bruleur

Lubrifier le moteur au moins une fois durant la saison de chauffage à l'aide d'une huile de grade SAE 20.

5.1.1.2 Filtre à huile

Il est recommendé de remplacer le filtre à huile à chaque année.

5.1.1.3 Gicleur

Si le gicleur se salit ou se bouche, il y aura absence d'allumage ou mauvaise combustion. L'une ou l'autre de ces conditions est détectable par les odeurs qu'elles causent. Dans ce cas le gicleur doit être remplacé.

5.1.1.4 Réservoir d'huile

Vérifier régulièrement le niveau de mazout dans le réservoir. Si, par mégarde, le réservoir se vidait completement, l'air devra être completement évacué du conduit d'admission d'huile.

5.1.2 Nettoyage des surfaces de chauffe

Pour nettoyer les surfaces de chauffe, i.e. la chambre à combustion et l'échangeur de chaleur, procéder de la facon suivante.

5.1.2.1 Echangeur de chaleur

Pour nettoyer l'échangeur de chaleur (12 tubes verticaux) il suffit d'enlever le tuyau à fumée et la boite à fumée. Les tubes peuvent être brossés à l'aide d'une brosse pour tuyaux de 2 pouces de diamètre. Il est recommandé de nettoyer l'échangeur de chaleur en premier car il est possible que les saletés tombent dans la chambre à combustion lors du nettoyage.

5.1.2.2 Chambre à combustion

Pour nettoyer la chambre à combustion il suffit de retirer le bruleur et d'aspirer les saletés à l'aide d'un aspirateur.

5.1.3 Précautions à prendre

Ne bruler jamais de déchets ou de papiers dans votre chaudière. N'accumuler pas de déchets ou de papiers à proximité de votre chaudière.

5.2 Unité Chauffage-ventilation

L'entretien recommandé pour l'unité chauffage-ventilation est détaillé dans les paragraphes suivants.

5.2.1 Moteur du ventilateur

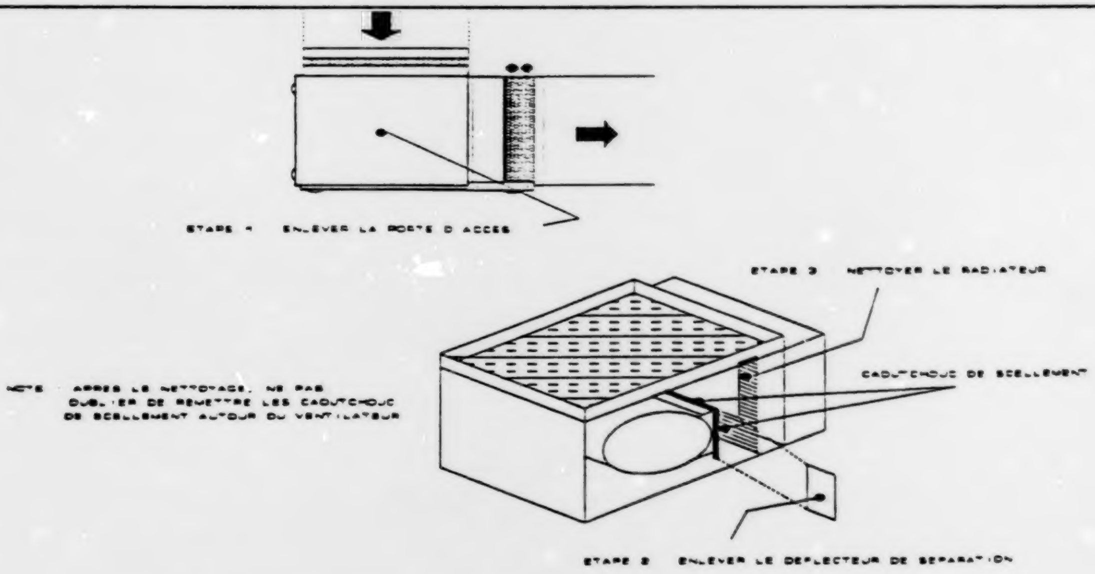
Lubrifier le moteur au moins une fois durant la saison de chauffage à l'aide d'une huile de grade SAE 20.

5.2.2 Filtre à air

Nettoyez le filtre à air au moins deux fois durant la saison de chauffage. Si celui est trop sale changez le par un modèle equivalent. Référez à la figure no. 18 pour l'accès au filtre à air. Si votre unité est muni d'un filtre électrostatique (Dust-Eater par exemple) lavable, vous pouvez laver celui-ci selon les instructions du manufacturier de filtre.

5.2.3 Nettoyage du serpentin

Le serpentin ne devrait pas se salir si le filtre à air est en bon état. Cependant si le serpentin de chauffage vient à se salir ou à se bloquer suivez la procédure suivante pour le nettoyer. Veuillez consulter la figure no. 18.


ETAPE 1 ENLEVER LA PORTE D ACCES
ETAPE 3 NETTOYER LE RADIATEUR
CAOUTCHOUC DE SCELLEMENT
NOTE : APRES LE NETTOYAGE, NE PAS OUBLIER DE REMETTRE LES CAOUTCHOUC DE SCELLEMENT AUTOUR DU VENTILATEUR
ETAPE 2 ENLEVER LE DEFLECTEUR DE SEPARATION

NETTOYAGE DE L'UNITE CHAUFFAGE-VENTILATION

FIGURE #18

5.4 Contrôle MP 2001

Le contrôle MP 2001 ne nécessite aucun entretien si ce n'est de vous assurer qu'il n'y a pas d'accumulation de poussières dans le panneau de contrôle. Il est important, pour assurer une longue vie aux composantes de fermer le panneau de contrôle lorsque le système est en fonction. Ceci est d'autant plus important qu'il y a de la haute tension présente sur la carte de puissance et qu'un contact avec une pièce haute tension peut provoquer de sérieuses blessures.

Section 6 Troubleshooting - Procédure de dépannage

Vous trouverez dans cette section les principales causes des problèmes possibles au système ainsi que des solutions de dépannages.

6.1 Organigramme de fonctionnement normal

De par sa conception le système AIR 2001 n'opère pas comme un système conventionnel et par le fait même son fonctionnement normal peut-être interprété comme défectueux par une personne n'étant pas familière avec le système. Veuillez consulter l'organigramme no 5 pour le fonctionnement général normal du système. Il est évident que pour des raisons de secret professionnel et de confidentialité nous ne pouvons mettre à la disposition du public l'organigramme complet du système. Les questions spécifiques sur le fonctionnement du système AIR 2001 devront être adressées au personnel technique de DETTSON qui se fera un plaisir de répondre à vos questions sur les heures normales d'ouvertures de bureau.

6.2 Troubleshooting général

Consulter l'organigramme général no 1 de facon à diagnostiquer de facon plus précise votre problème.

6.3 Troubleshooting en mode chauffage

Consulter les organigrammes no 2.1 & 2.2 pour un problème sur la partie chauffage de votre système AIR 2001.

6.4 Troubleshooting de l'eau chaude domestique

Consulter l'organigramme no 3 pour un problème d'approvisionnement en eau chaude domestique.

6.5 Troubleshooting en mode climatisation

Consulter l'organigramme no 4 pour un problème sur la partie climatisation de votre système AIR 2001.

6.6 Bruleur

Pour tout problème avec le bruleur, consulter la section 3.2.2 .

6.7 Renseignements sur le contrôle MP 2001

Dans les paragraphes suivants, la vérification, la calibration et l'ajustement des sondes seront discutés. Cette section devra être consulté lors de la calibration ou le remplacement des sondes. Il est primordial que toute sonde qui est remplacé soit recalibré. Si la carte de contrôle est changé toutes les sondes doivent être changées ou recalibrées.

De plus, ce paragraphe peut servir de référence lors d'une vérification totale en profondeur du système.

Important : Toute sonde fournie avec le contrôle MP 2001 est calibré en usine et ne devrait pas avoir à être recalibré lors de l'installation.

6.7.1 Bornier de diagnostic

La carte de contrôle du MP 2001 est muni d'un bornier de diagnostic qui est localisé près du micro-processeur principal (voir la figure 13). Les fiches de diagnostic sont numérotés de 1 à 10, 1 étant la plus haute. Voici la liste des fonctions de ces fiches.

- Fiche 1 Sonde de température de chaudière (CH)
- Fiche 2 Sonde température ambiante zone 2 (TA2)
- Fiche 3 Sonde température ambiante zone 1 (TA1)
- Fiche 4 Sonde de plénum zone 1 (TS1)
- Fiche 5 Sonde de plénum zone 2 (TS2)
- Fiche 7 Différentiel de réchauffement (DR)
- Fiche 8 Point de consigne (TC)
- Fiche 9 Référence analogue digitale (A/D)
- Fiche 10 Mise à la terre

6.7.2 Vérifications et ajustements

6.7.2.1 Référence A/D

La lecture d'un voltmètre digital entre la fiche 9 et la fiche 10 doit donner 3.31 V DC. Ceci est la référence analogue digitale de la carte de contrôle. Pour ajuster si nécessaire, utiliser un petit tournevis micrométrique et tourner dans le sens des aiguilles d'une montre dans le potentiomètre identifié A/D pour augmenter la valeur. Pour la location de ce potentiomètre consulter la figure 13.

6.7.2.2 Sonde de la chaudière

La température de la chaudière est lue à l'aide de la sonde à l'arrière de la chaudière. Cette sonde doit être ajustée précisemment. Pour avoir la lecture de la température de la chaudière, mesurez le voltage DC entre la fiche 1 et la fiche 10 et référez vous au tableau 9. Par exemple, si vous mesurez 2.11 V DC cela donne 163 degrés F en consultant le tableau 9.

Pour calibrer cette sonde, il suffit de la tremper dans un mélange d'eau et de glace (température de 32 degrés F). Après avoir attendu quelques instants que la température du mélange se stabilise, prendre la lecture entre les fiches 1 et 10. La lecture devrait être de 0.41 V DC. Si ce n'est pas le cas, calibrez la sonde à l'aide du potentiomètre CH.

Temp. (F)	Voltage (VDC)	Temp. (F)	Voltage (VDC)	Temp. (F)	Voltage (VDC)	Temp. (F)	Voltage (VDC)
0	0.000	72	0.936	116	1.508	160	2.080
1	0.013	73	0.949	117	1.521	161	2.093
30	0.390	74	0.962	118	1.534	162	2.106
31	0.403	75	0.975	119	1.547	163	2.119
32	0.416	76	0.988	120	1.560	164	2.132
33	0.429	77	1.001	121	1.573	165	2.145
34	0.442	78	1.014	122	1.586	166	2.158
35	0.455	79	1.027	123	1.599	167	2.171
36	0.468	80	1.040	124	1.612	168	2.184
37	0.481	81	1.053	125	1.625	169	2.197
38	0.494	82	1.066	126	1.638	170	2.210
39	0.507	83	1.079	127	1.651	171	2.223
40	0.520	84	1.092	128	1.664	172	2.236
41	0.533	85	1.105	129	1.677	173	2.249
42	0.546	86	1.118	130	1.690	174	2.262
43	0.559	87	1.131	131	1.703	175	2.275
44	0.572	88	1.144	132	1.716	176	2.288
45	0.585	89	1.157	133	1.729	177	2.301
46	0.598	90	1.170	134	1.742	178	2.314
47	0.611	91	1.183	135	1.755	179	2.327
48	0.624	92	1.196	136	1.768	180	2.340
49	0.637	93	1.209	137	1.781	181	2.353
50	0.650	94	1.222	138	1.794	182	2.366
51	0.663	95	1.235	139	1.807	183	2.379
52	0.676	96	1.248	140	1.820	184	2.392
53	0.689	97	1.261	141	1.833	185	2.405
54	0.702	98	1.274	142	1.846	186	2.418
55	0.715	99	1.287	143	1.859	187	2.431
56	0.728	100	1.300	144	1.872	188	2.444
57	0.741	101	1.313	145	1.885	189	2.457
58	0.754	102	1.326	146	1.898	190	2.470
59	0.767	103	1.339	147	1.911	191	2.483
60	0.780	104	1.352	148	1.924	192	2.496
61	0.793	105	1.365	149	1.937	193	2.509
62	0.806	106	1.378	150	1.950	194	2.522
63	0.819	107	1.391	151	1.963	195	2.535
64	0.832	108	1.404	152	1.976	196	2.548
65	0.845	109	1.417	153	1.989	197	2.561
66	0.858	110	1.430	154	2.002	198	2.574
67	0.871	111	1.443	155	2.015	199	2.587
68	0.884	112	1.456	156	2.028	200	2.600
69	0.897	113	1.469	157	2.041	210	2.730
70	0.910	114	1.482	158	2.054	225	2.925
71	0.923	115	1.495	159	2.067	250	3.250

Conversion voltage/temperature
Tableau no. 9

6.7.2.3 Point de consigne

Il est intéressant de connaitre exactement le point de consigne de la chaudière. Rappelons que le point de consigne est fixé par l'utilisateur au moyen du potentiomètre TC.

Pour connaitre ce point de consigne, mesurez la tension entre les fiches 8 et 10 du bornier de diagnostic et référez vous au tableau 10. Par exemple, si vous mesurez 0.55 V DC, cela signifie par le biais du tableau 10, un point de consigne de 165 degrés F.

Voltage (V DC)	Température (degrés F)	Voltage (V DC)	Température (degrés F)
0.00	160	1.76	176
0.11	161	1.87	177
0.22	162	1.98	178
0.33	163	2.09	179
0.44	164	2.20	180
0.55	165	2.31	181
0.66	166	2.42	182
0.77	167	2.53	183
0.88	168	2.64	184
0.99	169	2.75	185
1.10	170	2.86	186
1.21	171	2.97	187
1.32	172	3.08	188
1.43	173	3.19	189
1.54	174	3.30	190
1.65	175		

Voltage pour le point de consigne
Tableau 10

6.7.2.4 Sonde de plénum - zone 1

La température dans le bonnet de sortie de la zone 1 (plénum) est mesuré à l'aide de la sonde de plénum de la zone correspondante. Il est possible d'obtenir cette température en mesurant le voltage DC entre les fiches 4 et 10 sur le bornier de diagnostic et référer au tableau 9 plus haut. Par exemple, si vous mesurez 1.49 V DC, cela signifie une température de sortie d'air pour la zone 1 de 115 degrés F.

La procédure d'ajustement de cette sonde est la même (sonde dans la glace) que pour la sonde de température de chaudière sauf que le potentiomètre d'ajustement est TS1 (voir figure 13).

6.7.2.5 Sonde de plénum - zone 2

Les mesures et la procédure pour la sonde de la deuxième zone sont identiques à celles de la zone 1 discutée au paragraphe précédent. La mesure de voltage se fait entre les fiches 5 et 10 du bornier de diagnostic et le potentiomètre à ajuster est identifié TS2.

6.7.2.6 Sonde ambiante - zone 1

La température ambiante dans la zone 1 est obtenue grâce à la sonde de température ambiante installé près d'une bouche de retour dans la zone 1. Il est possible d'obtenir cette température en mesurant le voltage entre les fiches 3 et 10 du bornier de diagnostic et se référer au tableau 11 plus bas. Par exemple, si vous lisez 1.95 V DC cela équivaut à une température ambiante de 70 degrés F.

Pour ajuster la sonde de température ambiante, il suffit de prendre la température à proximité de la sonde (à l'aide d'un thermomètre par exemple) ou sur le thermostat (il faut s'assurer de la précision de cette lecture) et la comparer au voltage obtenu. Si y a un écart entre les deux lectures de plus de 2 degrés F, ajustez la sonde à la valeur du thermomètre par le biais du potentiomètre TA1.

Attention : Si vous utilisez un thermomètre pour calibrer cette sonde, laissez au moins 5 minutes au thermomètre pour qu'il atteigne une valeur stable.

6.7.2.7 Sonde ambiante - zone 2

Les mesures et la procédure pour la sonde de la deuxième zone sont identiques à celles de la zone 1 discutée au paragraphe précédent. La mesure de voltage se fait entre les fiches 2 et 10 du bornier de diagnostic et le potentiomètre à ajuster est identifié TA2.

6.8 Défectuosité de sonde

Si une des sondes du système est défectueuse, le voyant lumineux identifié "TROUBLES" sur la carte de contrôle clignotera. Si cela se produit faites les vérifications de sonde pour déterminer laquelle est défectueuse. Une fois la sonde fautive identifiée, changez la. **Toute nouvelle sonde installé sur la carte de contrôle en remplacement doit être calibré à l'aide des procédures discutées dans ce chapitre.**

6.9 Fusible basse tension

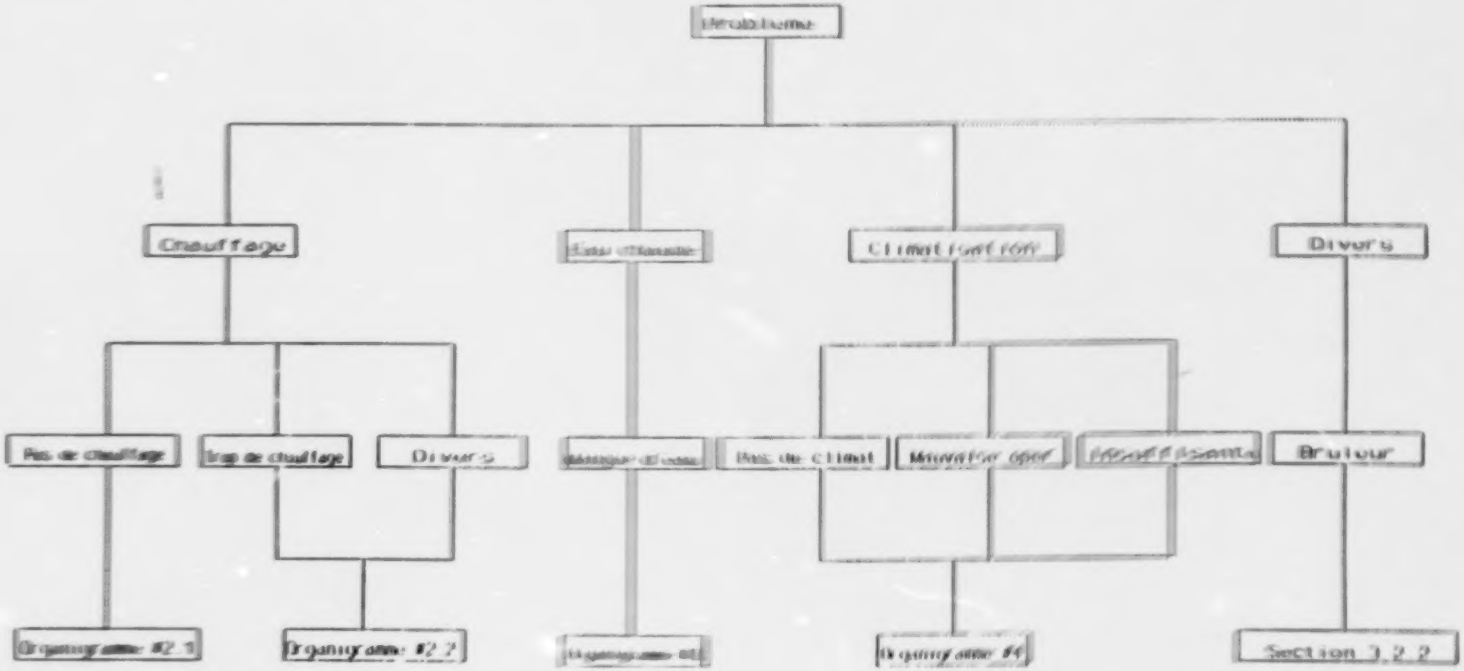
La carte de contrôle est muni d'un fusible basse tension de 2 ampères qui protège la carte. Si ce fusible est sauté, remplacez par un équivalent après avoir déterminé la cause du bris. Un fusible défectueux est facilement détectable car si tel est le cas il n'y a aucun voyant qui allume sur le panneau de contrôle même si celui-ci est énergisé.

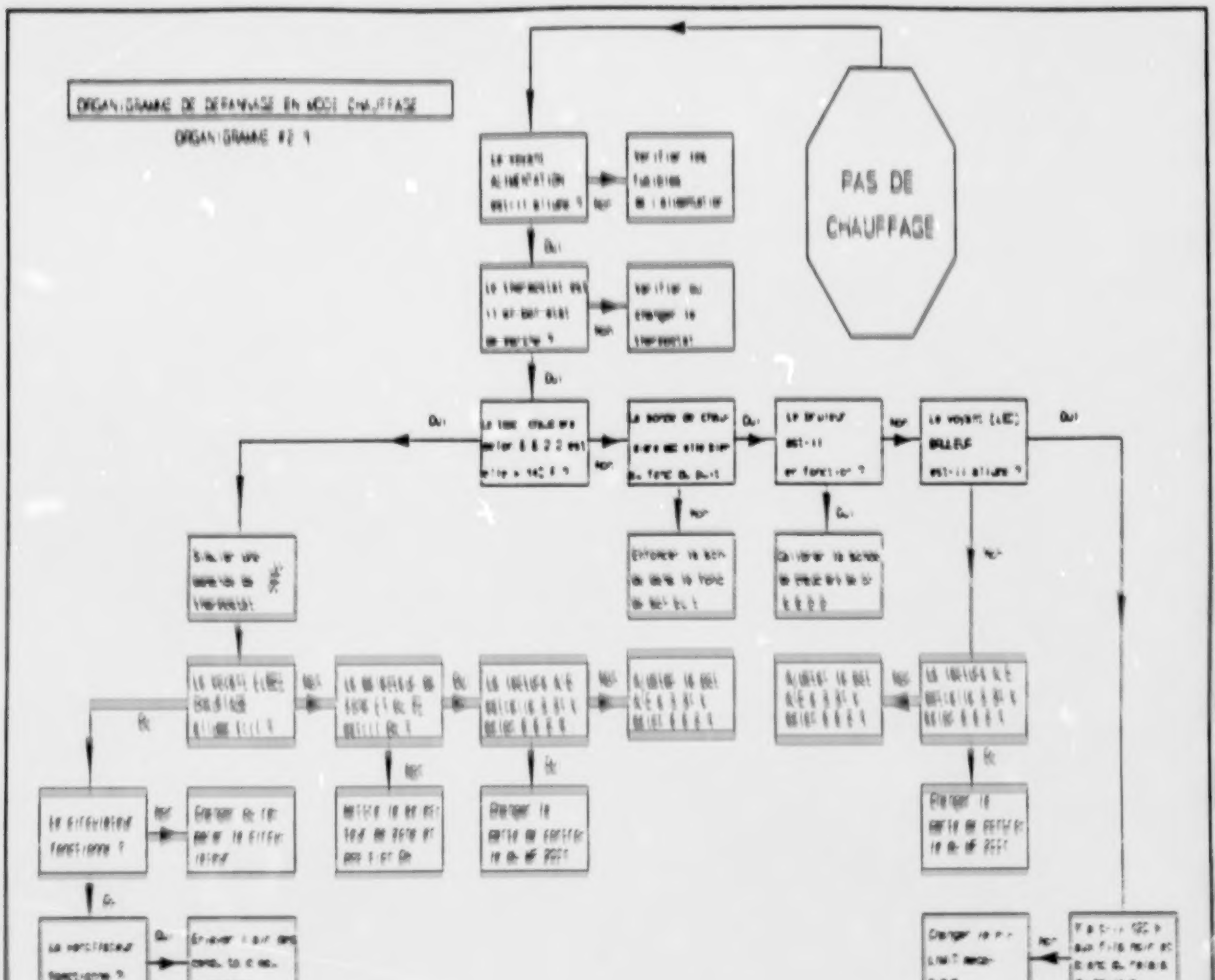
Voltage (V DC)	Température (degrés F)	Voltage (V DC)	Température (degrés F)
0.00	55	1.82	69
0.13	56	1.95	70
0.26	57	2.08	71
0.39	58	2.21	72
0.52	59	2.34	73
0.65	60	2.47	74
0.78	61	2.60	75
0.91	62	2.73	76
1.04	63	2.86	77
1.17	64	2.99	78
1.30	65	3.12	79
1.43	66	3.25	80
1.56	67	3.38	81
1.69	68		

Voltage pour la température ambiante
Tableau 11

ORGANIGRAMME GENERAL DE DEPANNAGE

ORGANIGRAMME #1


Problème
Chauffage
Eau chaude
Climatisation
Divers
Pas de chauffage
Trop de chauffage
Divers
Manque d'eau
Pas de climat
Mauvaise opér
Insuffisante
Bruleur
Organigramme #2.1
Organigramme #2.2
Organigramme #3
Organigramme #4
Section 3.2.2



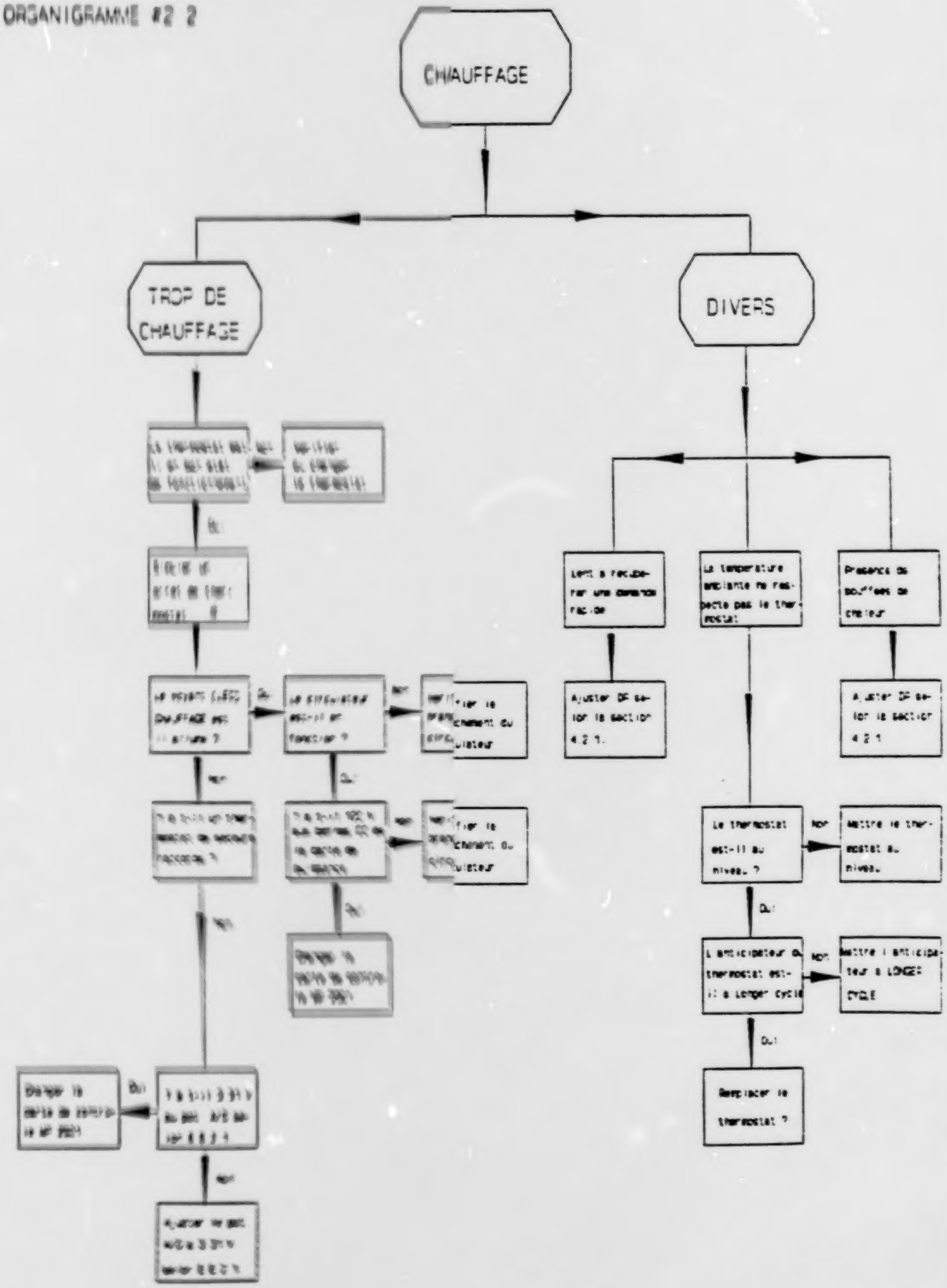
ORGANIGRAMME DE DEPANNAGE EN MODE CHAUFFAGE

ORGANIGRAMME #2.1

PAS DE CHAUFFAGE
Le voyant ALIMENTATION est-il allumé ?
Non
Vérifier les fusibles de l'alimentation
Oui
Le thermostat est-il en bon état de marche ?
Non
Vérifier ou changer le thermostat
Oui
Non
Oui
Le brûleur est-il en fonction ?
Non
Le voyant (LED) BRULEUR est-il allumé ?
Oui
Non
Oui
Non
Oui
Non
Oui
Non
Oui
Non
Oui
Non
Oui
Non
Oui

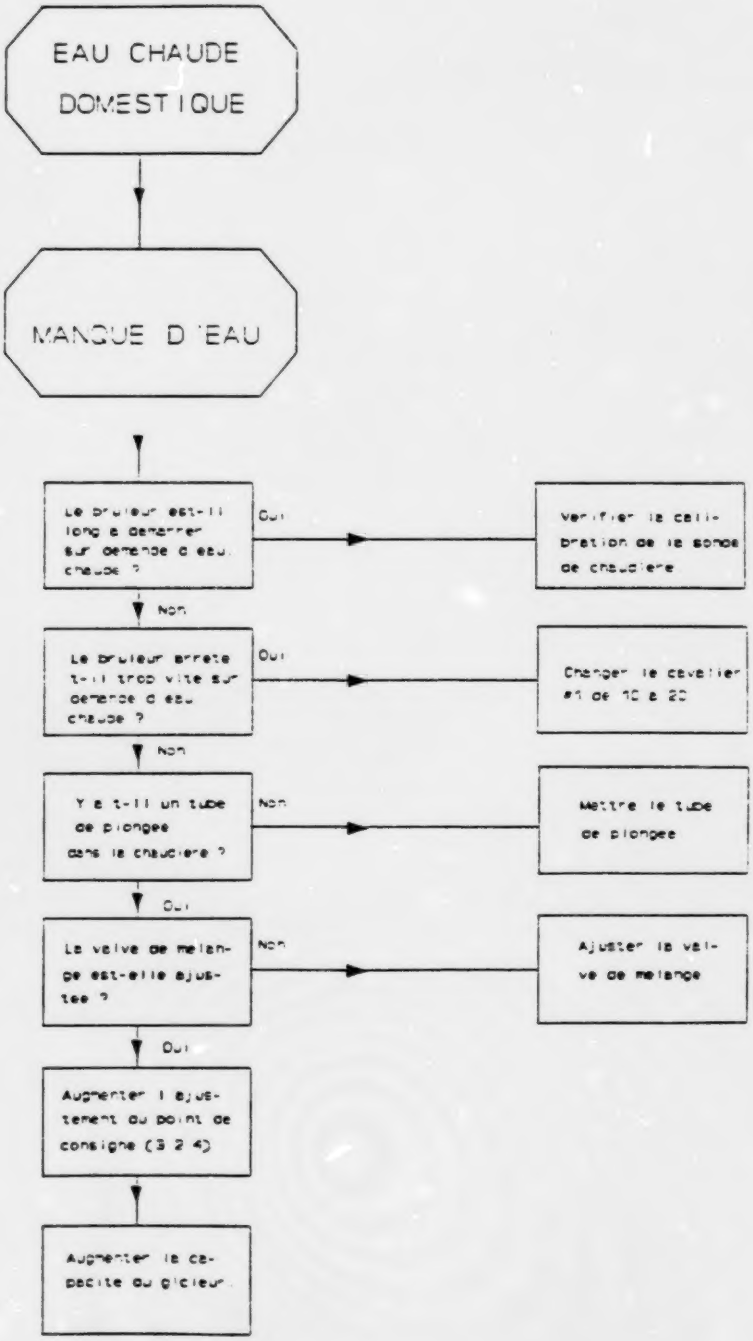
ORGANIGRAMME DE DEPANNAGE EN MODE CHAUFFAGE

ORGANIGRAMME #2 2


CHAUFFAGE
TROP DE CHAUFFAGE
DIVERS
Oui
Non
Oui
Non
Oui
Non
Non
Oui
Oui
Non
fier le chement du ulateur
fier le chement du ulateur
Ajuster le
Lent à récupérer une demande rapide
La température ambiante ne respecte pas le thermostat
Présence de bouffées de chaleur
Ajuster DF selon la section 4.2.1.
Ajuster DF selon la section 4.2.1
Le thermostat est-il au niveau ?
Non
Mettre le thermostat au niveau.
Oui
L'anticipateur du thermostat est-il à Longer cycle
Non
Mettre l'anticipateur à LONGER CYCLE
Oui
Remplacer le thermostat ?

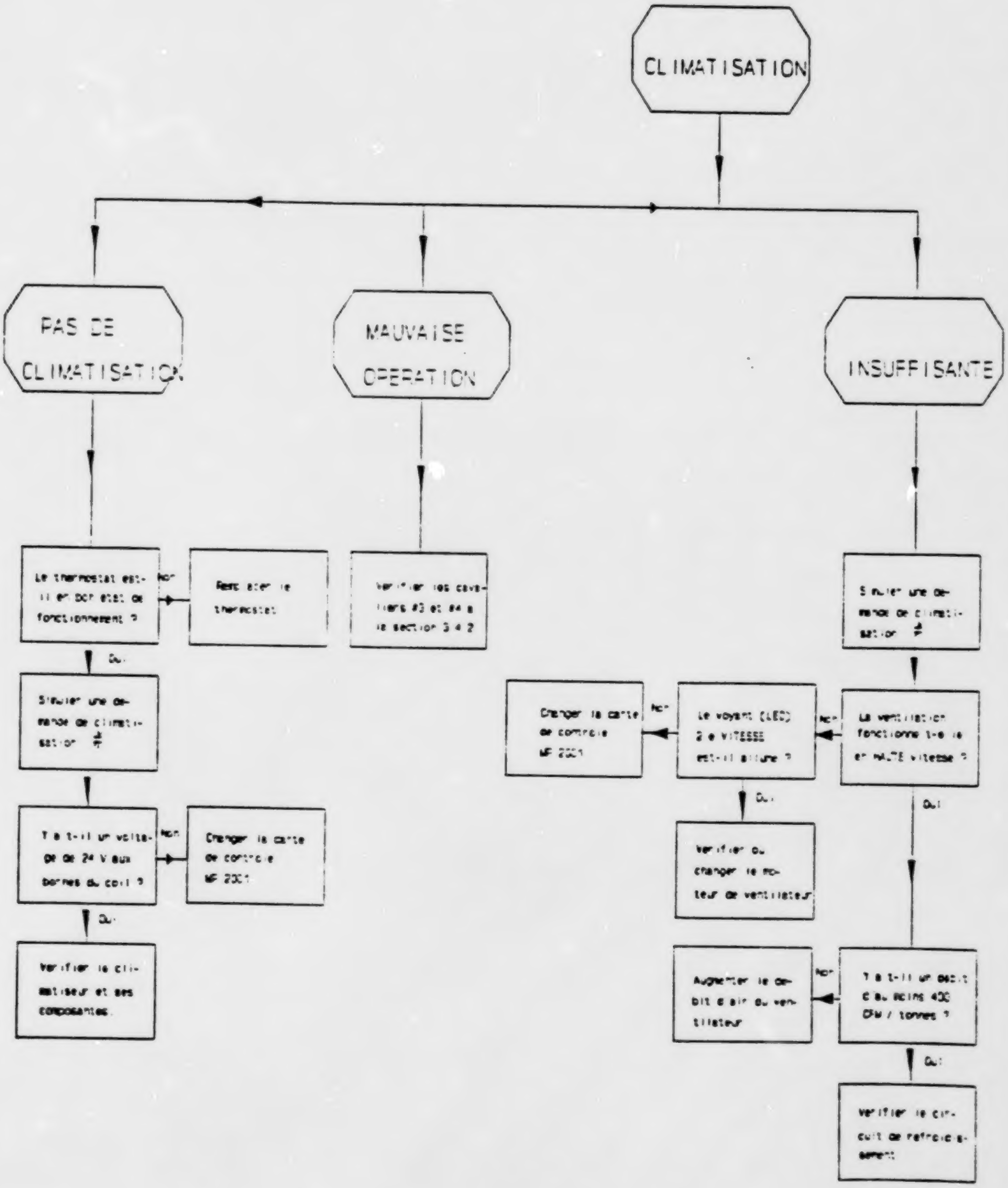
ORGANIGRAMME DE DEPANNAGE EN MODE EAU DOMESTIQUE

ORGANIGRAMME #3


EAU CHAUDE DOMESTIQUE
MANQUE D'EAU
Le bruleur est-il long a demarrer sur demande d eau chaude ?
Oui
Verifier la calibration de la sonde de chaudiere
Non
Le bruleur arrete t-il trop vite sur demande d eau chaude ?
Oui
Changer le cavalier #1 de 10 a 20
Non
Y a t-il un tube de plongee dans la chaudiere ?
Non
Mettre le tube de plongee
Oui
La valve de melange est-elle ajustee ?
Non
Ajuster la valve de melange
Oui
Augmenter l ajustement du point de consigne (3 2 4)
Augmenter la capacite du gicleur.

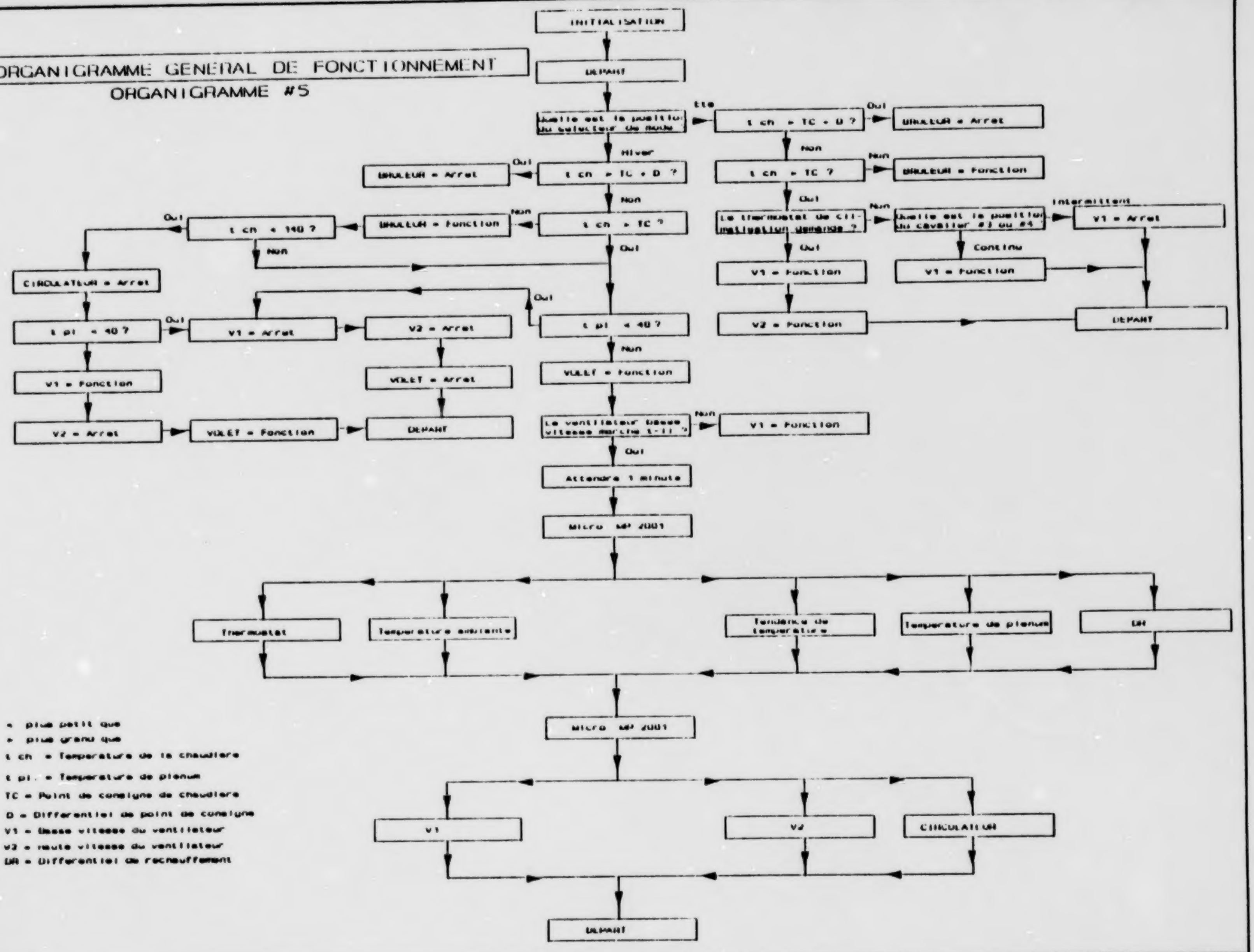
ORGANIGRAMME DE DEPANNAGE EN MODE CLIMATISATION

ORGANIGRAMME #4


CLIMATISATION
PAS DE CLIMATISATION
MAUVAISE OPERATION
INSUFFISANTE
Le thermostat est-il en bon etat de fonctionnement ?
Non
Remplacer le thermostat
Oui
Simuler une demande de climatisation #
Y a t-il un voltage de 24 V aux bornes du coil ?
Non
Changer la carte de controle MF 2001
Oui
Verifier le climatiseur et ses composantes.
Verifier les cavaliers #3 et #4 a la section 3.4.2
Simuler une demande de climatisation #
La ventilation fonctionne-t-elle en HAUTE vitesse ?
Non
Le voyant (LED) 2e VITESSE est-il allume ?
Non
Changer la carte de controle MF 2001
Oui
Verifier ou changer le moteur de ventilateur
Oui
Y a t-il un debit d'au moins 400 CFM / tonnes ?
Non
Augmenter le debit d'air du ventilateur
Oui
Verifier le circuit de refroidissement

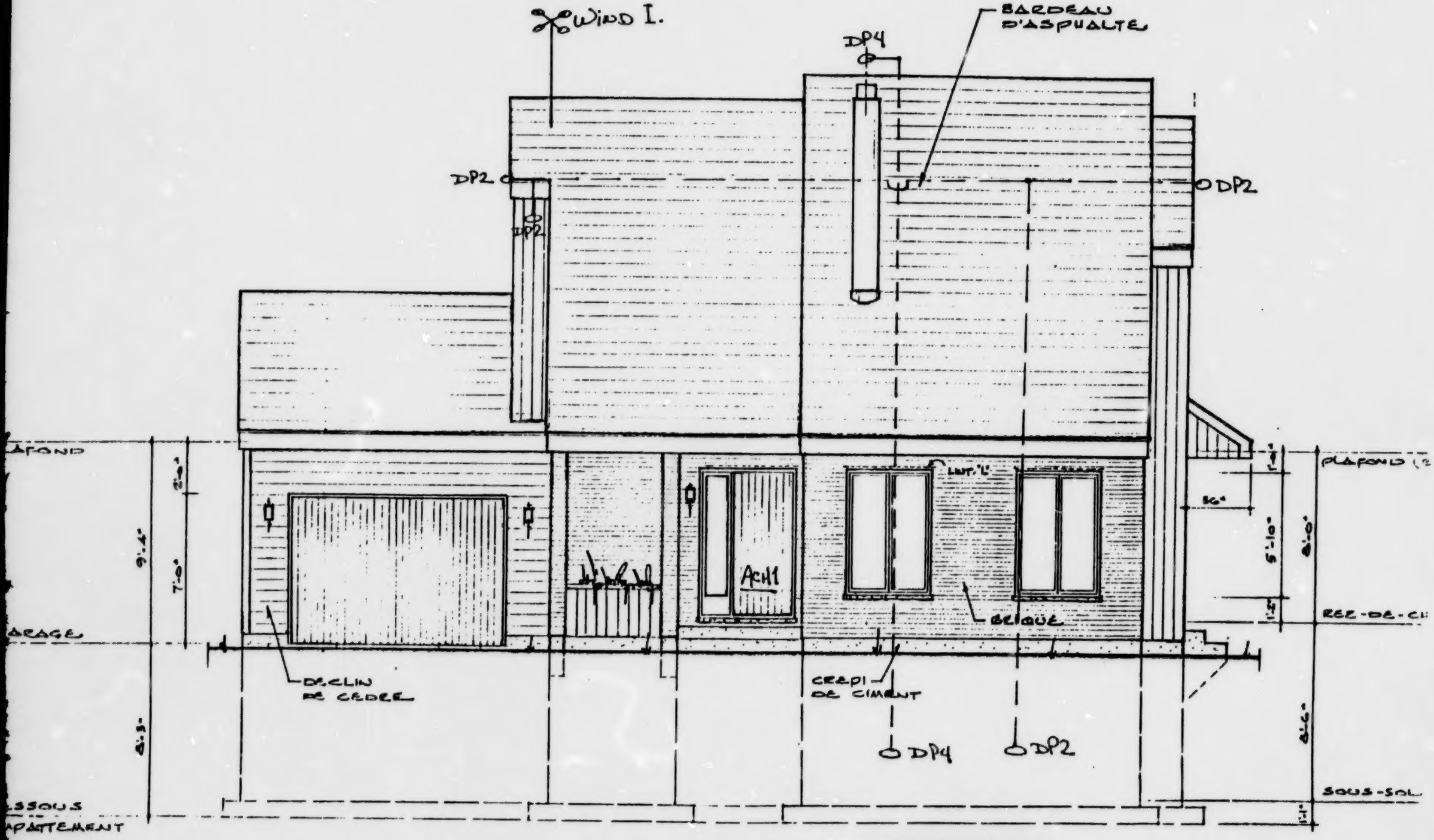
ORGANIGRAMME GENERAL DE FONCTIONNEMENT

ORGANIGRAMME #5

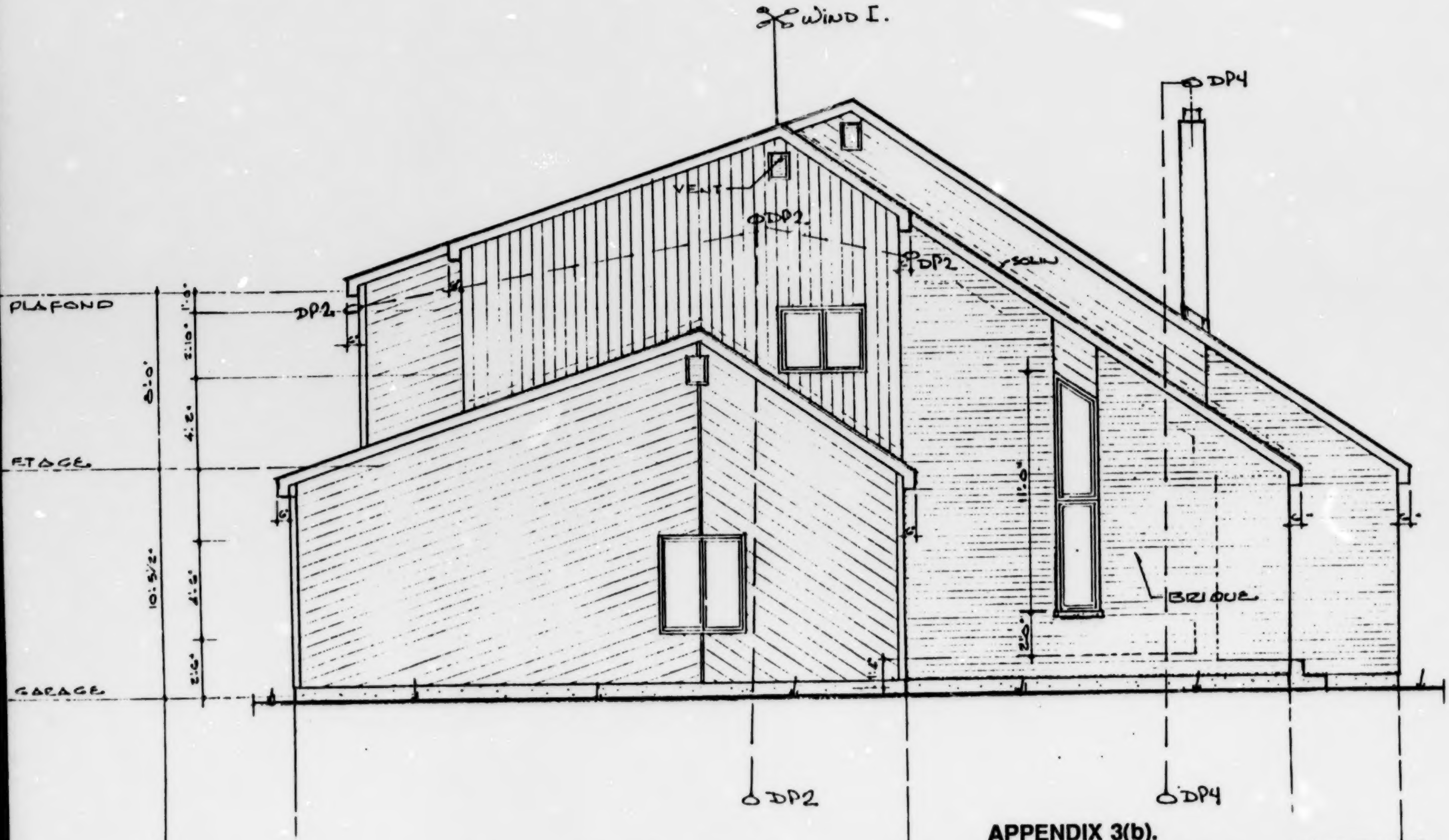

INITIALISATION
DEPART
Quelle est la position du selecteur de mode
Ete
Hiver
t ch > TC + D ?
Oui
BRULEUR = Arret
Non
t ch > TC ?
Non
BRULEUR = Fonction
t ch < 140 ?
Oui
CIRCULATEUR = Arret
t pl = 40 ?
Oui
V1 = Arret
V2 = Arret
VOLET = Arret
DEPART
V1 = Fonction
V2 = Arret
VOLET = Fonction
DEPART
Non
Oui
t pl < 40 ?
Oui
Non
VOLET = Fonction
Le ventilateur basse vitesse marche t-1 ?
Non
V1 = Fonction
Oui
Attendre 1 minute
Micro MP 2001
Thermostat
Temperature ambiante
Tendance de temperature
Temperature de plenum
DR
Micro MP 2001
V1
V2
CIRCULATEUR
DEPART
t ch > TC + D ?
Oui
BRULEUR = Arret
Non
t ch > TC ?
Non
BRULEUR = Fonction
Oui
Le thermostat de climatisation demande ?
Non
Quelle est la position du cavalier #3 ou #4 ?
Intermittent
V1 = Arret
Continu
V1 = Fonction
Oui
V1 = Fonction
V2 = Fonction
DEPART

< plus petit que
> plus grand que
t ch = Temperature de la chaudiere
t pl. = Temperature de plenum
TC = Point de consigne de chaudiere
D = Differentiel de point de consigne
V1 = Basse vitesse du ventilateur
V2 = Haute vitesse du ventilateur
DR = Differentiel de rechauffement

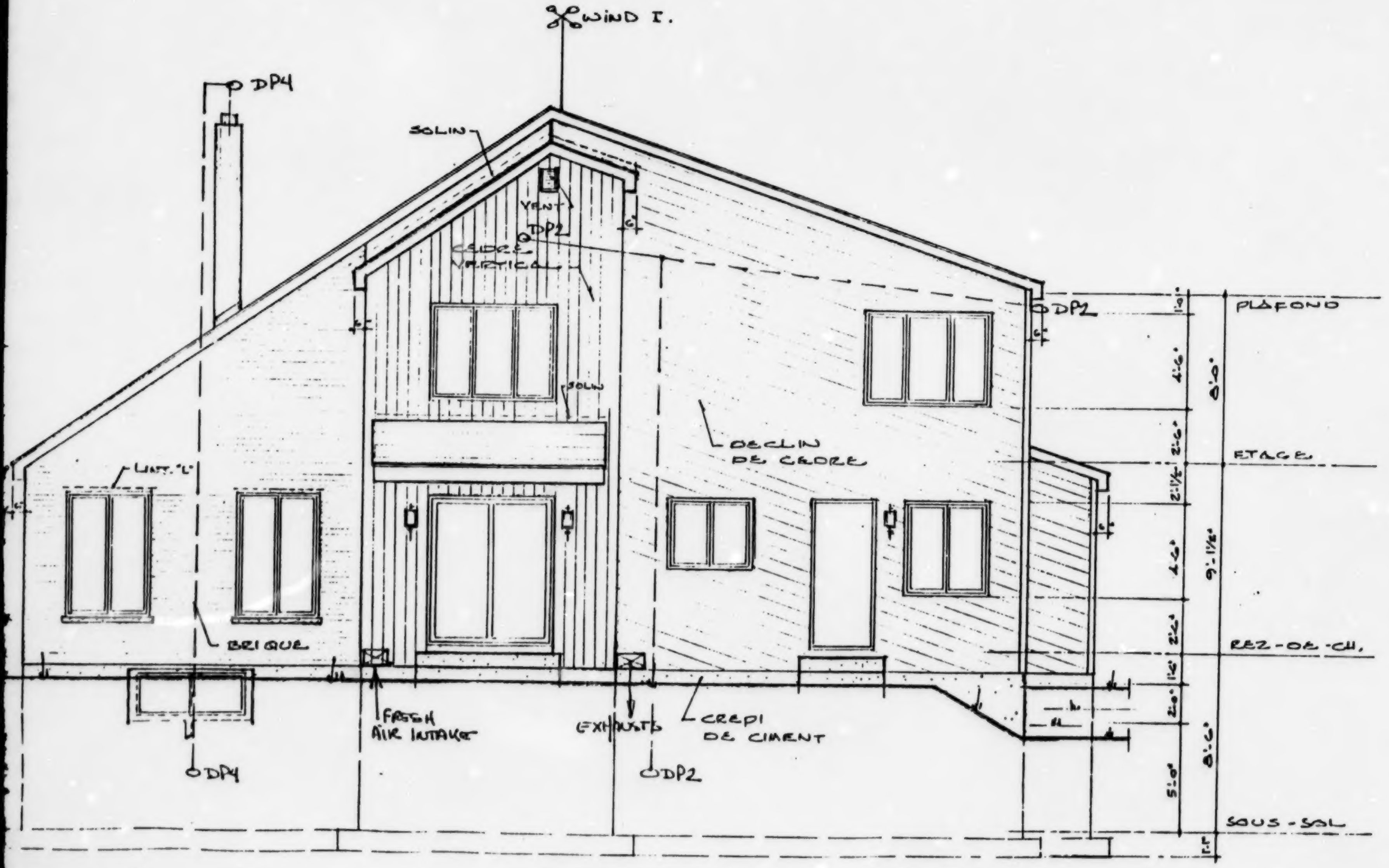
APPENDIX 3.
Eight views of test home with location of sensors


WIND I.
BARDEAU D'ASPHALTE
DP4
DP2
DP2
DP2
LINT. "L"
ACH1
BRIQUE
DECLIN DE CEDRE
CREPI DE CIMENT
DP4
DP2
AFOND
ARAGE
SSOUS
APPARTEMENT
PLAFOND
REZ-DE-CH
SOUS-SOL
9'-4"
7'-0"
8'-5"
36"
5'-10"
8'-0"
8'-6"
1'-1"

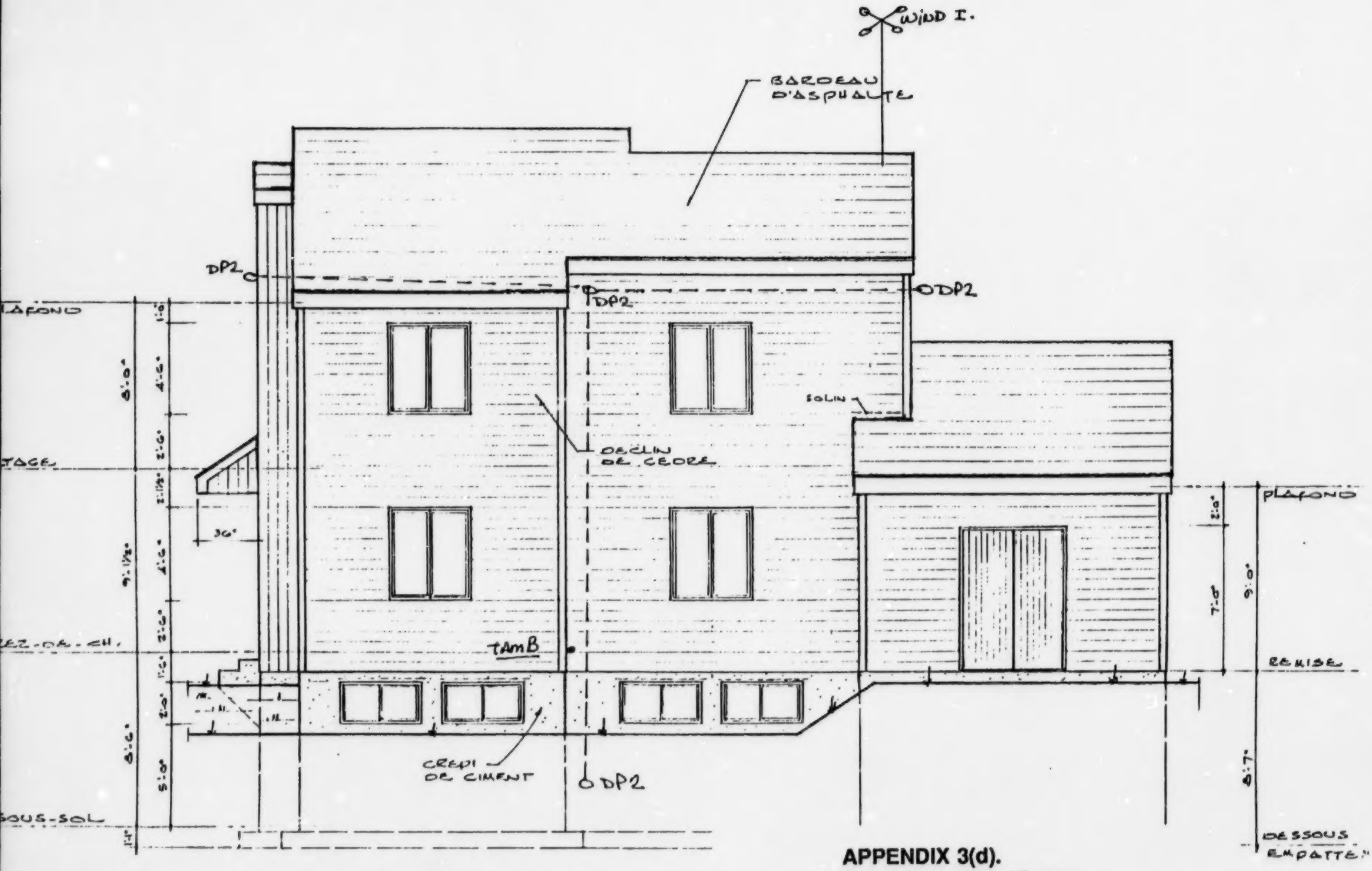
APPENDIX 3(a).
Front view of test home


WIND I.
DP4
VENT
DP2
DP2
DP2
SOLIN
PLAFOND
ETAGE
GARAGE
BRIQUE
8'-0"
10'-5 1/2"
1'-0"
2'-10"
4'-2"
4'-2"
2'-6"
11'-0"
2'-0"
6"
4"
DP2
DP4

APPENDIX 3(b).
West view of test home

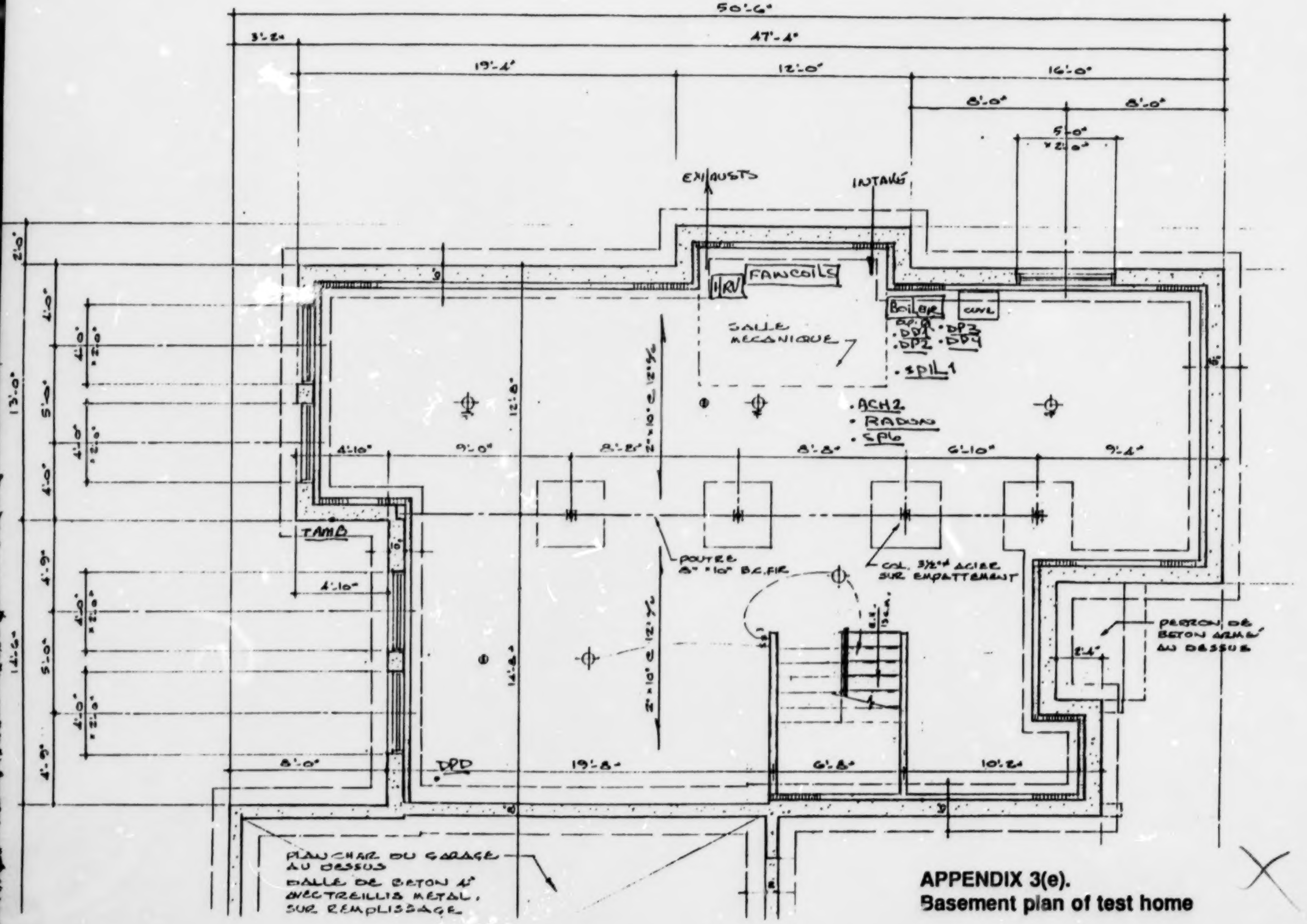

WIND I.
DP4
SOLIN
VENT
DP2
CEDRE VERTICAL
SOLIN
DP2
DECLIN DE CEDRE
LINT. "L"
BRIQUE
FRESH AIR INTAKE
EXHAUSTS
CREPI DE CIMENT
DP4
DP2
PLAFOND
ETAGE
REZ-DE-CH.
SOUS-SOL
1'-0"
4'-6"
2'-6"
2'-1½"
4'-6"
2'-6"
1'-2"
2'-0"
5'-0"
8'-0"
9'-1½"
8'-6"

APPENDIX 3(c).
East view of test home

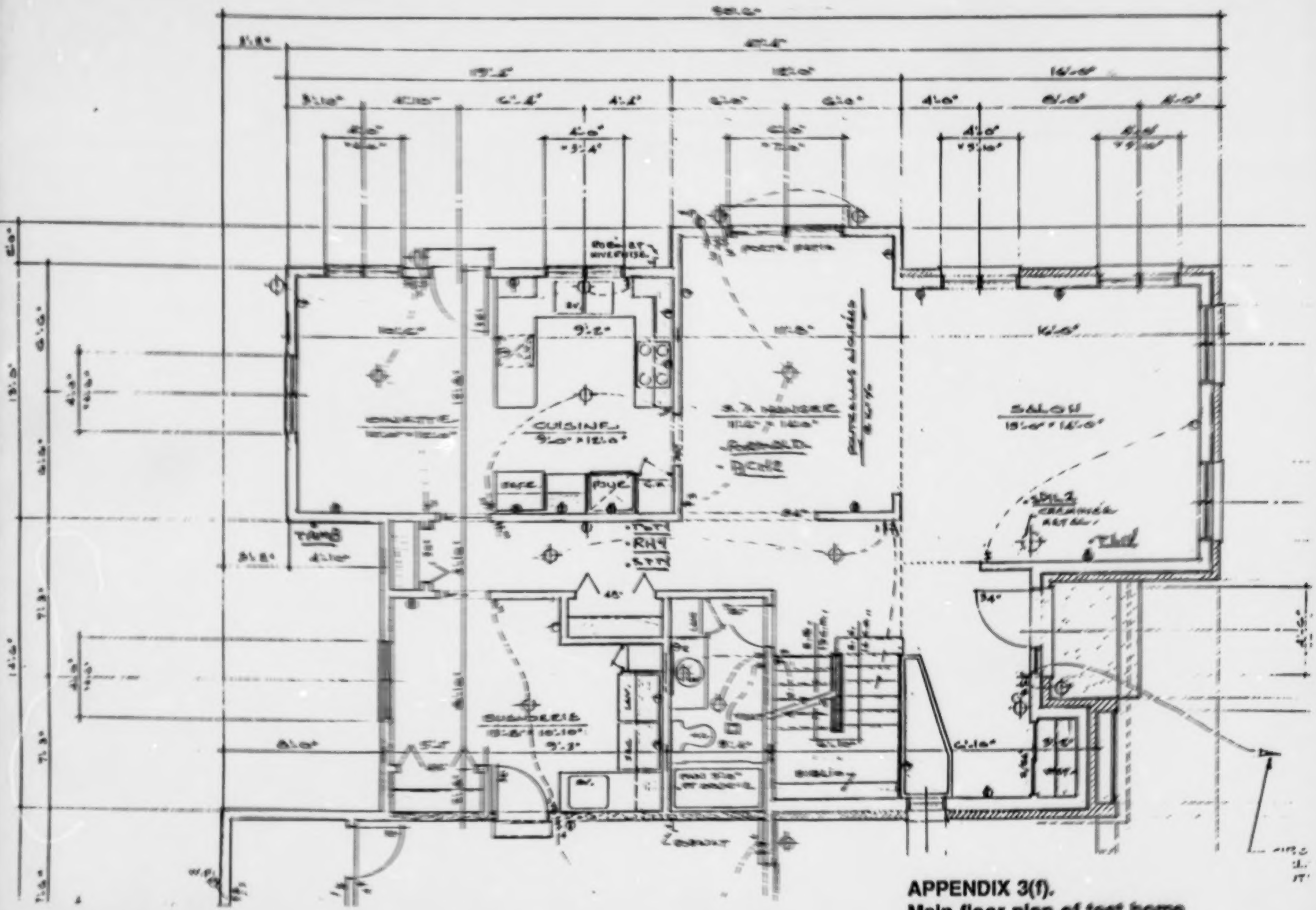


WIND I.
BARDEAU D'ASPHALTE
DP2
DP2
DP2
DP2
SOLIN
DECLIN DE CEDRE
TAMB
CREPI DE CIMENT
LAFOND
TAGE
EZ-DE-CH.
OUS-SOL
PLAFOND
REMISE
DESSOUS EMPATTE.
36"
1'-0"
4'-6"
2'-6"
4'-6"
2'-6"
1'-0"
2'-0"
5'-0"
8'-0"
9'-1½"
8'-6"
2'-0"
7'-0"
9'-0"
8'-7"

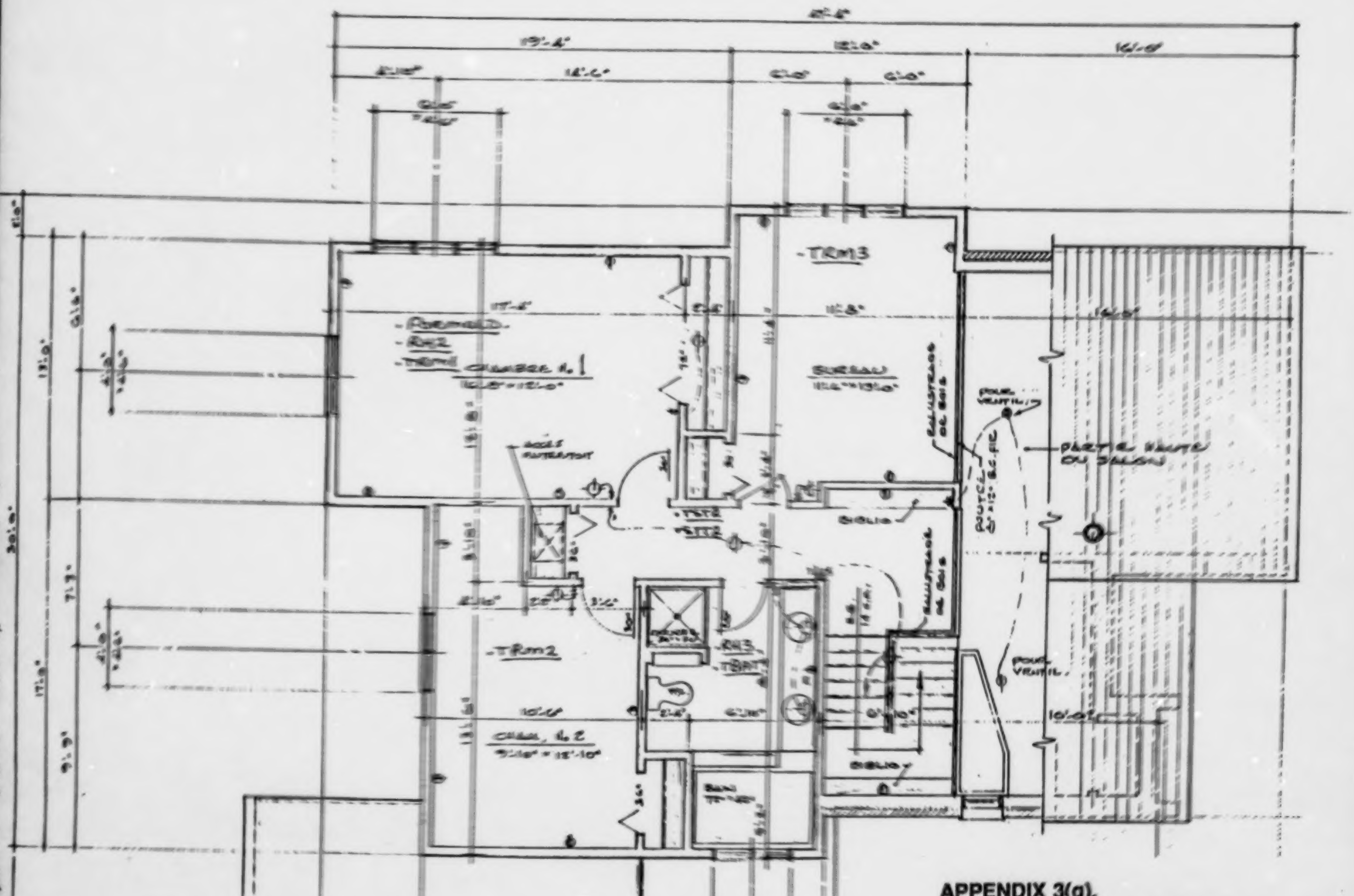
APPENDIX 3(d).
Rear view of test home


50'-6"
3'-2"
47'-4"
19'-4"
12'-0"
16'-0"
8'-0"
8'-0"
5'-0" × 2'-0"
EXHAUSTS
INTAKE
HRV
FANCOILS
Boiler
CWL
DP1
DP2
DP3
DP4
SALLE MECANIQUE
SPIL1
ACH2
RADON
SP6
4'-10"
9'-0"
8'-8"
2"×10" @ 12" %
8'-8"
6'-10"
9'-4"
12'-8"
14'-8"
POUTRE 8"×10" B.C.FIR
COL. 3½" ACIER SUR EMPATTEMENT
PERRON DE BETON ARMÉ AU DESSUS
2'-4"
TAMB
4'-10"
8'-0"
DPD
19'-8"
6'-8"
10'-2"
2'-0"
4'-0"
13'-0"
5'-0"
4'-0"
4'-0" × 2'-0"
4'-9"
14'-6"
5'-0"
4'-9"
PLANCHER DU GARAGE AU DESSUS
DALLE DE BETON 4" AVEC TREILLIS METAL. SUR REMPLISSAGE

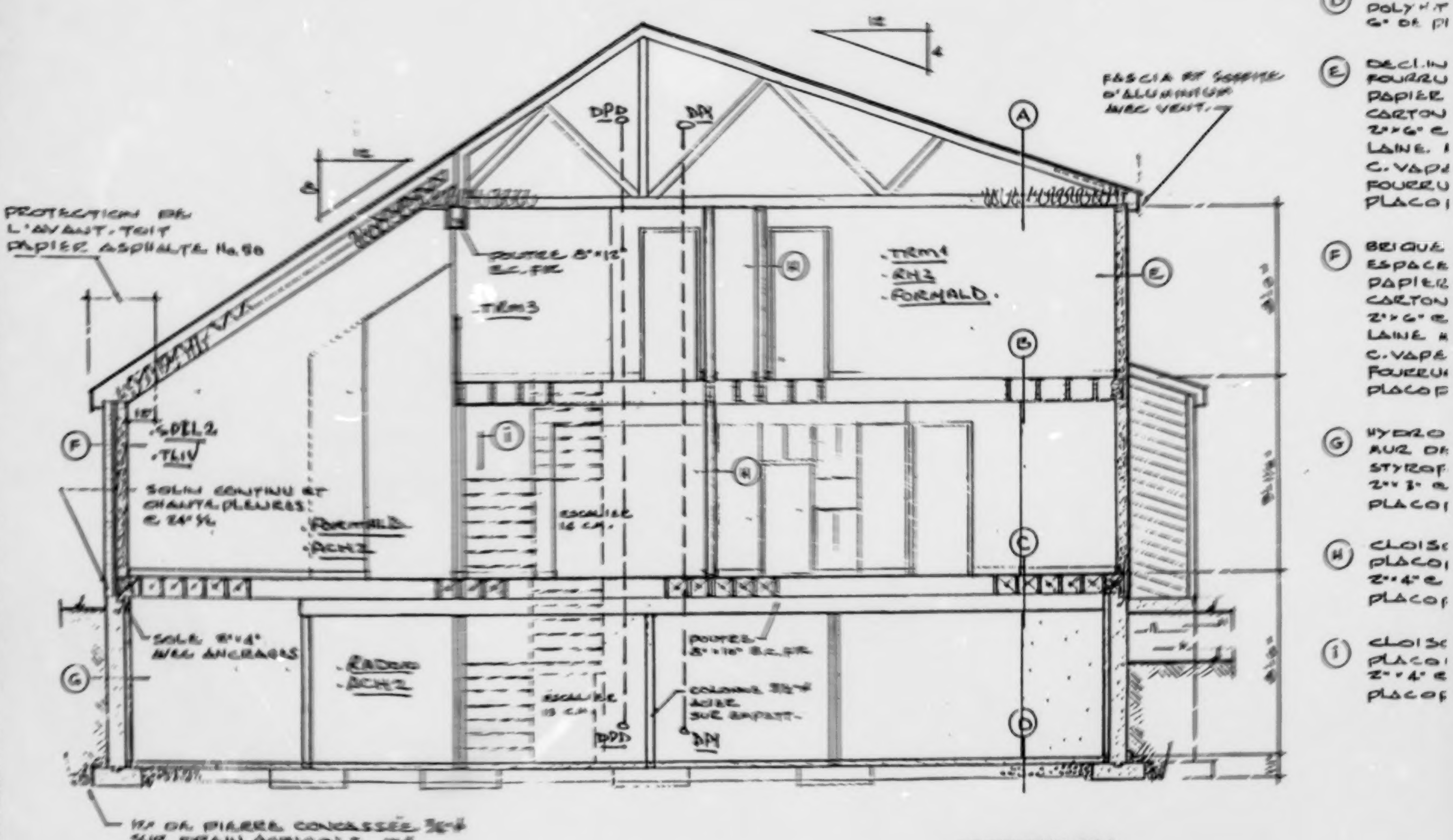
APPENDIX 3(e).
Basement plan of test home


SALON
15'-0" x 14'-0"
16'-0"
S. À MANGER
PORTE PATIO
CUISINE
9'-0" x 12'-0"
9'-2"
DINETTE
BUANDERIE
RH4

APPENDIX 3(f).
Main floor plan of test home


19'-4"
12'-0"
16'-6"
6'-0"
6'-0"
12'-6"
-TRM3
BUREAU
-TRM2
CHAMBRE N. 1
CHAM. N. 2
BALUSTRADE DE BOIS
BIBLIO
POUR VENTIL.
PARTIE HAUTE DU SALON
POUTRE
ACCES ENTRETOIT
11'-8"
10'-6"
16'-0"
10'-0"
30'-0"
16'-3"

APPENDIX 3(g).
Second floor plan of test home


12
4
8
12
DPD
DM
A
B
C
D
E
F
G
H
I
FASCIA ET SOFFITE D'ALUMINIUM AVEC VENT.
PROTECTION DE L'AVANT-TOIT
PAPIER ASPHALTE No.50
POUTRE 8"×12" B.C. FR
TRM3
TRM1
RH2
FORMALD.
SDEL2
TLIV
SOLIN CONTINU ET CHANTE-PLEURES @ 24" c/c
FORMALD
ACH2
ESCALIER 16 CM.
SOLE 8"×4" AVEC ANCRAGES
RADON
ACH2
ESCALIER 18 CM.
POUTRE 8"×10" B.C. FR
COLONNE 3½" ACIER SUR EMPATT.
DPD
DM
1½" DE PIERRE CONCASSÉE ¾"-¼" SUR DRAIN AGRICOLE 4" Ø EN PLASTIQUE
DALLE
POLY
6" DE P
DECLIN
FOURRU
PAPIER
CARTON
2"×6" @
LAINE
C. VAPE
FOURRU
PLACO
BRIQUE
ESPACE
PAPIER
CARTON
2"×6" @
LAINE
C. VAPE
FOURRU
PLACO
HYDRO
MUR DE
STYROF
2"×3" @
PLACO
CLOISO
PLACO
2"×4" @
PLACO
CLOISO
PLACO
2"×4" @
PLACO

APPENDIX 3(h).
Cross-section (East) of test home

APPENDIX 4.
HOT2000 simulation
Test home without ventilation
Electrical and oil heating

```
                    *************************************
                    *                                   *
                    *             HOT-2000              *
                    *           Version 5.04            *
                    * Energy, Mines and Resources Canada *
                    *        September 01, 1987         *
                    *                                   *
                    *************************************

DATE (mm/dd/yy): 01/25/91
CLIENT NAME     : MAISON BRAIS / ROUSSEL
ADDRESS         : 923 de la Pommeraie,STHILAIRE

HOUSE DATA FILENAME: pomm001
WEATHER DATA IS FOR: Montreal (Quebec)

                  *** TEMPERATURE AND BUILDING MASS ***

HEATING TEMPERATURES      MAIN FLOOR                  = 18 C
                          BASEMENT                    = 17 C
                          TEMP. SWING FROM 18 C       = .5 C

SOIL TYPE: Normal Conductivity: dry sand, loam, clay, low water table

HOUSE THERMAL MASS LEVEL: (1) Wood frame construction, 12.5 mm gyproc walls
                              and ceiling, wooden floor

            *** FOUNDATION CONSTRUCTION CHARACTERISTICS ***

FOUNDATION CONSTRUCTION     ATTACHMENT SIDES    INSULATION PLACEMENT

FULL BASEMENT                  1 SIDE                 INTERIOR

                *** WINDOW/GLAZING CHARACTERISTICS ***

ORIENTATION   AVERAGE      AVERAGE       AVERAGE   AVERAGE    AVERAGE
              # GLAZINGS   TRANSMISSION  WINDOW    OVERHANG   HEADER
                           COEFFICIENT   HEIGHT    WIDTH      HEIGHT
                                            m         m          m

Southeast       2.00          .71         1.43       .24        .04
Southwest       2.00          .70         1.37       .00        .00
Northeast       2.00          .75
Northwest       2.00          .70
```

```
                              *** BUILDING PARAMETERS ***

COMPONENT                               AREA        RSI              HEAT LOSS   % ANNUAL
                                         m2                             MJ       HEAT LOSS
-----------------------------------------------------------------------------------------

ABOVE GRADE COMPONENTS

Ceiling
                                        44.05       7.38
                                        70.10       6.98
                                          .65        .53
                        TOTAL:         114.80       6.66                6710        8.20

Main walls
                                       184.28       4.63
                                        14.98       6.94
                                         6.58        .70
                        TOTAL:         205.84       4.01               18334       22.40

Doors
                                         3.50       2.00
                                         1.75       3.00
                        TOTAL:           5.25       2.25                 908        1.11

Basement walls above grade
                                          .58        .70
                                        18.52       2.25
                                         2.79       3.37
                        TOTAL:          21.89       2.21                3535        4.32

FULL DEPTH BASEMENT

Upper basement walls
                                        29.37       1.11
                        TOTAL:          29.37       1.11                5208        6.36

Lower basement walls
                                        61.59       1.11
                        TOTAL:          61.59       1.11                7736        9.45

Floor perimeter
                                        43.50       1.03
                        TOTAL:          43.50       1.03                3605        4.41

Floor center
                                        54.30        .20
                        TOTAL:          54.30        .00                4905        5.99
```

```
WINDOWS/GLAZING              GLAZING        RSI           HEAT LOSS   % ANNUAL
                             AREA (m2)  GLAZING (SHUTTER)    MJ       HEAT LOSS


Southeast windows
                                7.78       .53 ( .15)
                                3.00       .53 ( .15)
                                 .79       .36
                     TOTAL:    11.57       .51 ( .13)      7780          9.51

Southwest windows
                                3.85       .53 ( .15)
                     TOTAL:     3.85       .53 ( .15)      2473          3.02

Northeast windows
                                5.16       .53 ( .15)
                                2.53       .36
                     TOTAL:     7.69       .46 ( .07)      6051          7.39

Northwest windows
                                2.28       .53 ( .15)
                     TOTAL:     2.28       .53 ( .15)      1465          1.79

AIR LEAKAGE AND                              AIR          HEAT LOSS   % ANNUAL
VENTILATION                  VOLUME        CHANGE            MJ       HEAT LOSS


                             720.00 m3     .14 ACH         13553        16.56

                     *** AIR LEAKAGE AND VENTILATION  ***

BUILDING ENVELOPE SURFACE AREA                                 =   561.9 m2
AIR LEAKAGE TEST RESULTS AT 50 Pa.(0.2 in. H2O)                =    2.90 ACH
EQUIVALENT LEAKAGE AREA                                        = 650 cm2
BUILDING ENVELOPE IS NOT SHELTERED FROM THE WIND.

 AVERAGE VENTILATION RATE (Unbalanced)                        = 0 ACH ( 0 L/s)
```

```
                         *** SPACE HEATING SYSTEM ***

PRIMARY SPACE HEATING FUEL IS : ELECTRICITY
SPACE HEATING EQUIPMENT       : Forced air furnace

SPACE HEATING EQUIPMENT MANUFACTURER       :
SPACE HEATING EQUIPMENT MODEL              :
SPACE HEATING EQUIPMENT OUTPUT CAPACITY    =          kW
AVERAGE SEASONAL EFFICIENCY                = 100 %

                      *** ANNUAL SPACE HEATING SUMMARY ***

DESIGN HEAT LOSS AT  -23 C                                  =   8.28 kW

GROSS SPACE HEATING LOAD                                    = 81832 MJ
SENSIBLE DAILY HEAT GAIN FROM OCCUPANTS                     =  2.80 kWh/day
USABLE INTERNAL GAINS                                       = 15000 MJ
USABLE INTERNAL GAINS FRACTION                              =    18 %
USABLE SOLAR GAINS                                          = 19537 MJ
USABLE SOLAR GAINS FRACTION                                 =    24 %
AUXILIARY ENERGY REQUIRED                                   = 47295 MJ
VENTILATION EQUIPMENT ELECTRICAL CONTRIBUTION                =     0 MJ
FURNACE/BOILER ANNUAL ENERGY CONSUMPTION                    = 47295 MJ

                     *** DOMESTIC WATER HEATING SYSTEM ***

PRIMARY WATER HEATING FUEL    : ELECTRICITY
WATER HEATING EQUIPMENT       : Electric tank

WATER HEATING EQUIPMENT MANUFACTURER       :
WATER HEATING EQUIPMENT MODEL              :
WATER HEATING EQUIPMENT TANK CAPACITY      =  182 Litres
SEASONAL EFFICIENCY                        = 93 %

                  *** ANNUAL DOMESTIC WATER HEATING SUMMARY ***

DAILY HOT WATER CONSUMPTION                                   = 240 Litres/day
ESTIMATED DOMESTIC WATER HEATING LOAD                         = 17422 MJ

PRIMARY DOMESTIC WATER HEATING ENERGY CONSUMPTION             = 18733 MJ


                    *** LIGHTING AND APPLIANCES SUMMARY ***

DAILY ELECTRICAL LOAD                                         = 9 kWh/day
ESTIMATED ANNUAL ENERGY CONSUMPTION                           = 3285 kWh
```

```
         *** R-2000 HOME PROGRAM ENERGY CONSUMPTION SUMMARY REPORT ***

ESTIMATED ANNUAL SPACE HEATING ENERGY CONSUMPTION    = 47295 MJ    = 13138 kWh
VENTILATOR ELECTRICAL CONSUMPTION: HEATING HOURS     =     0 MJ    =     0 kWh
ESTIMATED ANNUAL DHW HEATING ENERGY CONSUMPTION      = 18733 MJ    =  5204 kWh

ESTIMATED ANNUAL SPACE + DHW ENERGY CONSUMPTION      = 66029 MJ    = 18341 kWh
ANNUAL R-2000 SPACE + DHW ENERGY CONSUMPTION TARGET = 66040 MJ    = 18344 kWh

ESTIMATED ANNUAL BASE ELECTRICAL ENERGY CONSUMPTION = 11826 MJ    =  3285 kWh
VENTILATOR ELECTRICAL CONSUMPTION: NON HEATING HOURS=     0 MJ    =     0 kWh


               *** ESTIMATED ANNUAL FUEL CONSUMPTION SUMMARY ***

FUEL                    SPACE HEATING + DHW HEATING + APPLIANCES  =  TOTAL

ELECTRICITY  (kWh)          13138          5204          3285      = 21626 kWh


                           *********************

     Energy units: MJ = Megajoules (3.6 MJ = 1 kWh)

     The calculated heat losses and energy consumptions are only
     estimates, based upon the data entered and assumptions within the
     program.   Actual energy consumption and heat losses will be
     influenced by construction practices, localized weather, equipment
     characteristics and the lifestyle of the occupants.
```

```
                         *** MONTHLY ENERGY PROFILE ***

MONTH     ENERGY LOAD    INTERNAL GAINS  SOLAR GAINS    AUX ENERGY REQ HRV EFF.
              MJ               MJ             MJ              MJ           %
--------------------------------------------------------------------------------
 Jan        14550             1387           2531           10632         .0
 Feb        12736             1252           2940            8544         .0
 Mar        11170             1387           3375            6409         .0
 Apr         7380             1342           2442            3596         .0
 May         3703             1387           1444             873         .0
 Jun         1456             1123            333               0         .0
 Jul          882              808             74               0         .0
 Aug          980              878            103               0         .0
 Sep         2180             1323            854               4         .0
 Oct         5290             1387           1672            2231         .0
 Nov         8614             1342           1718            5554         .0
 Dec        12690             1387           2051            9453         .0
```

```
*****************************************
*                                       *
*               HOT-2000                *
*             Version 5.04              *
*  Energy, Mines and Resources Canada   *
*          September 01, 1987           *
*                                       *
*****************************************

DATE (mm/dd/yy): 01/25/91
CLIENT NAME     : MAISON BRAIS / ROUSSEL
ADDRESS         : 923 de la Pommeraie.STHILAIRE

HOUSE DATA FILENAME: pomm006
WEATHER DATA IS FOR: Montreal (Quebec)

                     *** TEMPERATURE AND BUILDING MASS ***

HEATING TEMPERATURES      MAIN FLOOR                 = 18 C
                          BASEMENT                   = 17 C
                          TEMP. SWING FROM 18 C      = .5 C

SOIL TYPE: Normal Conductivity: dry sand, loam, clay, low water table

HOUSE THERMAL MASS LEVEL: (1) Wood frame construction, 12.5 mm gyproc walls
                              and ceiling, wooden floor

            *** FOUNDATION CONSTRUCTION CHARACTERISTICS ***

FOUNDATION CONSTRUCTION      ATTACHMENT SIDES    INSULATION PLACEMENT

FULL BASEMENT                    1 SIDE                INTERIOR

                  *** WINDOW/GLAZING CHARACTERISTICS ***

ORIENTATION    AVERAGE       AVERAGE         AVERAGE    AVERAGE     AVERAGE
               # GLAZINGS    TRANSMISSION    WINDOW     OVERHANG    HEADER
                             COEFFICIENT     HEIGHT     WIDTH       HEIGHT
                                                m          m           m

Southeast         2.00           .71          1.43        .24         .04
Southwest         2.00           .70          1.37        .00         .00
Northeast         2.00           .75
Northwest         2.00           .70
```

```
                          *** BUILDING PARAMETERS ***

COMPONENT                    AREA       RSI            HEAT LOSS   % ANNUAL
                              m2                          MJ       HEAT LOSS
------------------------------------------------------------------------------

ABOVE GRADE COMPONENTS

Ceiling
                             44.05      7.38
                             70.10      6.98
                               .65       .53
                  TOTAL:    114.80      6.66              6710        8.16

Main walls
                            184.28      4.63
                             14.98      6.94
                              6.58       .70
                  TOTAL:    205.84      4.01             18334       22.30

Doors
                              3.50      2.00
                              1.75      3.00
                  TOTAL:      5.25      2.25               908        1.10

Basement walls above grade
                               .58       .70
                             18.52      2.25
                              2.79      3.37
                  TOTAL:     21.89      2.21              3535        4.30

FULL DEPTH BASEMENT

Upper basement walls
                             29.37      1.11
                  TOTAL:     29.37      1.11              5208        6.33

Lower basement walls
                             61.59      1.11
                  TOTAL:     61.59      1.11              7736        9.41

Floor perimeter
                             43.50      1.03
                  TOTAL:     43.50      1.03              3605        4.39

Floor center
                             54.30       .20
                  TOTAL:     54.30       .00              4905        5.97
```

4

```
WINDOWS/GLAZING                      GLAZING       RSI            HEAT LOSS    % ANNUAL
                                    AREA (m2)  GLAZING (SHUTTER)     MJ       HEAT LOSS


Southeast windows
                                       7.78       .53 ( .15)
                                       3.00       .53 ( .15)
                                        .79       .36
                       TOTAL:         11.57       .51 ( .13)        7780         9.46

Southwest windows
                                       3.85       .53 ( .15)
                       TOTAL:          3.85       .53 ( .15)        2473         3.01

Northeast windows
                                       5.16       .53 ( .15)
                                       2.53       .36
                       TOTAL:          7.69       .46 ( .07)        6051         7.36

Northwest windows
                                       2.28       .53 ( .15)
                       TOTAL:          2.28       .53 ( .15)        1465         1.78

AIR LEAKAGE AND                                    AIR          HEAT LOSS    % ANNUAL
VENTILATION                          VOLUME      CHANGE            MJ       HEAT LOSS


                                   720.00 m3     .14 ACH          13553        16.49

                    *** AIR LEAKAGE AND VENTILATION  ***

BUILDING ENVELOPE SURFACE AREA                                 =    561.9 m2
AIR LEAKAGE TEST RESULTS AT 50 Pa.(0.2 in. H2O)                =     2.90 ACH
EQUIVALENT LEAKAGE AREA                                        = 650 cm2
BUILDING ENVELOPE IS NOT SHELTERED FROM THE WIND.

 AVERAGE VENTILATION RATE (Unbalanced)                        = 0 ACH ( 0 L/s)
```

```
                         *** SPACE HEATING SYSTEM ***

PRIMARY SPACE HEATING FUEL IS : OIL
SPACE HEATING EQUIPMENT       : Furnace/boiler with flame retention head

SPACE HEATING EQUIPMENT MANUFACTURER       :
SPACE HEATING EQUIPMENT MODEL              :
SPACE HEATING EQUIPMENT OUTPUT CAPACITY    = 0 kW
MANUFACTURER'S STEADY STATE EFFICIENCY     = 86 %
DERIVED SEASONAL EFFICIENCY                = 76 %

                     *** ANNUAL SPACE HEATING SUMMARY ***

DESIGN HEAT LOSS AT  -23 C                                =   8.28 kW

GROSS SPACE HEATING LOAD                                  = 82211 MJ
SENSIBLE DAILY HEAT GAIN FROM OCCUPANTS                   =  2.80 kWh/day
USABLE INTERNAL GAINS                                     = 35236 MJ
USABLE INTERNAL GAINS FRACTION                            =    43 %
USABLE SOLAR GAINS                                        = 15433 MJ
USABLE SOLAR GAINS FRACTION                               =    19 %
AUXILIARY ENERGY REQUIRED                                 = 31542 MJ
VENTILATION EQUIPMENT ELECTRICAL CONTRIBUTION             =     0 MJ
FURNACE/BOILER ANNUAL ENERGY CONSUMPTION                  = 41503 MJ

                   *** DOMESTIC WATER HEATING SYSTEM ***

PRIMARY WATER HEATING FUEL     : OIL
WATER HEATING EQUIPMENT        : Tankless coil: oil-fired

WATER HEATING EQUIPMENT MANUFACTURER       :
WATER HEATING EQUIPMENT MODEL              :
SEASONAL EFFICIENCY                        = 70 %

                *** ANNUAL DOMESTIC WATER HEATING SUMMARY ***

DAILY HOT WATER CONSUMPTION                                 = 240 Litres/day
ESTIMATED DOMESTIC WATER HEATING LOAD                       = 17422 MJ

PRIMARY DOMESTIC WATER HEATING ENERGY CONSUMPTION           = 24889 MJ


                  *** LIGHTING AND APPLIANCES SUMMARY ***

DAILY ELECTRICAL LOAD                                       = 36 kWh/day
ESTIMATED ANNUAL ENERGY CONSUMPTION                         = 13140 kWh
```

```
          *** R-2000 HOME PROGRAM ENERGY CONSUMPTION SUMMARY REPORT ***

ESTIMATED ANNUAL SPACE HEATING ENERGY CONSUMPTION    = 41503 MJ     = 11529 kWh
VENTILATOR ELECTRICAL CONSUMPTION: HEATING HOURS     =     0 MJ     =     0 kWh
ESTIMATED ANNUAL DHW HEATING ENERGY CONSUMPTION      = 24889 MJ     =  6914 kWh

ESTIMATED ANNUAL SPACE + DHW ENERGY CONSUMPTION      = 66392 MJ     = 18442 kWh
ANNUAL R-2000 SPACE + DHW ENERGY CONSUMPTION TARGET = 93759 MJ     = 26044 kWh

ESTIMATED ANNUAL BASE ELECTRICAL ENERGY CONSUMPTION = 47304 MJ     = 13140 kWh
VENTILATOR ELECTRICAL CONSUMPTION: NON HEATING HOURS=     0 MJ     =     0 kWh


               *** ESTIMATED ANNUAL FUEL CONSUMPTION SUMMARY ***

FUEL                   SPACE HEATING + DHW HEATING + APPLIANCES  =  TOTAL

OIL          (Litres)      1077            646            0      =  1723 Litres
ELECTRICITY  (kWh)            0              0        13140      = 13140 kWh

1 litre No. 2 Oil = 38.52 MJ or 10.7 kWh

                         *********************

     Energy units: MJ = Megajoules (3.6 MJ = 1 kWh)

     The calculated heat losses and energy consumptions are only
     estimates, based upon the data entered and assumptions within the
     program.   Actual energy consumption and heat losses will be
     influenced by construction practices, localized weather, equipment
     characteristics and the lifestyle of the occupants.
```

```
                          *** MONTHLY ENERGY PROFILE ***

MONTH     ENERGY LOAD      INTERNAL GAINS  SOLAR GAINS    AUX ENERGY REQ HRV EFF.
              MJ                 MJ             MJ              MJ           %
-------------------------------------------------------------------------------------
 Jan         14550              3944           2423            8184         .0
 Feb         12736              3562           2744            6430         .0
 Mar         11170              3944           2936            4291         .0
 Apr          7380              3806           1801            1774         .0
 May          3924              3146            778               0         .0
 Jun          1456              1423             33               0         .0
 Jul           882               881              1               0         .0
 Aug           980               977              4               0         .0
 Sep          2338              2158            181               0         .0
 Oct          5290              3637            960             693         .0
 Nov          8614              3816           1603            3194         .0
 Dec         12890              3944           1969            6977         .0
```

APPENDIX 5.
HOT2000 simulation
Test home with 0,15 ACH ventilation
Oil heating

```
                    ****************************************
                    *                                      *
                    *                HOT-2000              *
                    *             Version 5.04             *
                    *  Energy, Mines and Resources Canada  *
                    *          September 01, 1987          *
                    *                                      *
                    ****************************************

DATE (mm/dd/yy): 01/25/91
CLIENT NAME     : MAISON BRAIS / ROUSSEL
ADDRESS         : 923 de la Pommeraie,STHILAIRE

HOUSE DATA FILENAME: pomm002
WEATHER DATA IS FOR: Montreal (Quebec)

                     *** TEMPERATURE AND BUILDING MASS ***

HEATING TEMPERATURES     MAIN FLOOR                = 18 C
                         BASEMENT                  = 17 C
                         TEMP. SWING FROM 18 C     = .5 C

SOIL TYPE: Normal Conductivity: dry sand, loam, clay, low water table

HOUSE THERMAL MASS LEVEL: (1) Wood frame construction, 12.5 mm gyproc walls
                              and ceiling, wooden floor

             *** FOUNDATION CONSTRUCTION CHARACTERISTICS ***

FOUNDATION CONSTRUCTION     ATTACHMENT SIDES    INSULATION PLACEMENT

FULL BASEMENT                 1 SIDE                INTERIOR

                     *** WINDOW/GLAZING CHARACTERISTICS ***

ORIENTATION   AVERAGE      AVERAGE       AVERAGE   AVERAGE    AVERAGE
              # GLAZINGS   TRANSMISSION  WINDOW    OVERHANG   HEADER
                           COEFFICIENT   HEIGHT    WIDTH      HEIGHT
                                            m        m          m

Southeast       2.00           .71         1.43       .24        .04
Southwest       2.00           .70         1.37       .00        .00
Northeast       2.00           .75
Northwest       2.00           .70
```

```
                        *** BUILDING PARAMETERS ***

COMPONENT                           AREA        RSI              HEAT LOSS   % ANNUAL
                                     m2                             MJ       HEAT LOSS
-------------------------------------------------------------------------------------

ABOVE GRADE COMPONENTS

Ceiling
                                    44.05       7.38
                                    70.10       6.98
                                      .65        .53
                       TOTAL:      114.80       6.66                6710         7.50

Main walls
                                   184.28       4.63
                                    14.98       6.94
                                     6.58        .70
                       TOTAL:      205.84       4.01               18334        20.50

Doors
                                     3.50       2.00
                                     1.75       3.00
                       TOTAL:        5.25       2.25                 908         1.02

Basement walls above grade
                                      .58        .70
                                    18.52       2.25
                                     2.79       3.37
                       TOTAL:       21.89       2.21                3535         3.95

FULL DEPTH BASEMENT

Upper basement walls
                                    29.37       1.11
                       TOTAL:       29.37       1.11                5208         5.82

Lower basement walls
                                    61.59       1.11
                       TOTAL:       61.59       1.11                7736         8.65

Floor perimeter
                                    43.50       1.03
                       TOTAL:       43.50       1.03                3605         4.03

Floor center
                                    54.30        .20
                       TOTAL:       54.30        .00                4905         5.49
```

```
WINDOWS/GLAZING                   GLAZING       RSI                HEAT LOSS   % ANNUAL
                                 AREA (m2)  GLAZING (SHUTTER)       MJ        HEAT LOSS


Southeast windows
                                    7.78       .53 ( .15)
                                    3.00       .53 ( .15)
                                     .79       .36
                        TOTAL:     11.57       .51 ( .13)         7780          8.70

Southwest windows
                                    3.85       .53 ( .15)
                        TOTAL:      3.85       .53 ( .15)         2473          2.77

Northeast windows
                                    5.16       .53 ( .15)
                                    2.53       .36
                        TOTAL:      7.69       .46 ( .07)         6051          6.77

Northwest windows
                                    2.28       .53 ( .15)
                        TOTAL:      2.28       .53 ( .15)         1465          1.64


AIR LEAKAGE AND                                   AIR          HEAT LOSS   % ANNUAL
VENTILATION                        VOLUME        CHANGE          MJ        HEAT LOSS


                                  720.00 m3       .29 ACH       20772         23.23


                        *** AIR LEAKAGE AND VENTILATION  ***

BUILDING ENVELOPE SURFACE AREA                                   =   561.9 m2
AIR LEAKAGE TEST RESULTS AT 50 Pa.(0.2 in. H2O)                  =    2.90 ACH
EQUIVALENT LEAKAGE AREA                                          = 650 cm2
BUILDING ENVELOPE IS NOT SHELTERED FROM THE WIND.

 AVERAGE VENTILATION RATE (Balanced)                            = .15 ACH ( 30 L/s)
```

```
VENTILATION SYSTEM IS      : Mechanical ventilator and/or fans

MANUFACTURER: no-name brand
MODEL NUMBER: xxxxx

TOTAL ELECTRICAL POWER REQUIRED                                 = 0 Watts

GROSS AIR LEAKAGE AND VENTILATION ENERGY LOAD                   = 20772 MJ
SEASONAL HEAT RECOVERY VENTILATOR EFFICIENCY                    =     0 %
ESTIMATED VENTILATION ELECTRICAL LOAD: HEATING HOURS            =     0 MJ
ESTIMATED VENTILATION ELECTRICAL LOAD: NON-HEATING HOURS        =     0 MJ
NET AIR LEAKAGE AND VENTILATION ENERGY LOAD                     = 20772 MJ

                        *** SPACE HEATING SYSTEM ***

PRIMARY SPACE HEATING FUEL IS : OIL
SPACE HEATING EQUIPMENT       : Furnace/boiler with flame retention head

SPACE HEATING EQUIPMENT MANUFACTURER       :
SPACE HEATING EQUIPMENT MODEL              :
SPACE HEATING EQUIPMENT OUTPUT CAPACITY    = 0 kW
MANUFACTURER'S STEADY STATE EFFICIENCY     = 86 %
DERIVED SEASONAL EFFICIENCY                = 76 %

                    *** ANNUAL SPACE HEATING SUMMARY ***

DESIGN HEAT LOSS AT  -23 C                                 =   9.10 kW

GROSS SPACE HEATING LOAD                                   = 89428 MJ
SENSIBLE DAILY HEAT GAIN FROM OCCUPANTS                    =  2.60 kWh/day
USABLE INTERNAL GAINS                                      = 35732 MJ
USABLE INTERNAL GAINS FRACTION                             =    40 %
USABLE SOLAR GAINS                                         = 16410 MJ
USABLE SOLAR GAINS FRACTION                                =    18 %
AUXILIARY ENERGY REQUIRED                                  = 37286 MJ
VENTILATION EQUIPMENT ELECTRICAL CONTRIBUTION              =     0 MJ
FURNACE/BOILER ANNUAL ENERGY CONSUMPTION                   = 49061 MJ

                   *** DOMESTIC WATER HEATING SYSTEM ***

PRIMARY WATER HEATING FUEL    : OIL
WATER HEATING EQUIPMENT       : Tankless coil: oil-fired

WATER HEATING EQUIPMENT MANUFACTURER       :
WATER HEATING EQUIPMENT MODEL              :
SEASONAL EFFICIENCY                        = 70 %

                *** ANNUAL DOMESTIC WATER HEATING SUMMARY ***

DAILY HOT WATER CONSUMPTION                                   = 240 Litres/day
ESTIMATED DOMESTIC WATER HEATING LOAD                         = 17422 MJ

PRIMARY DOMESTIC WATER HEATING ENERGY CONSUMPTION             = 24889 MJ
```

```
                    *** LIGHTING AND APPLIANCES SUMMARY ***

DAILY ELECTRICAL LOAD                                       = 36 kWh/day
ESTIMATED ANNUAL ENERGY CONSUMPTION                         = 13140 kWh

          *** R-2000 HOME PROGRAM ENERGY CONSUMPTION SUMMARY REPORT ***

ESTIMATED ANNUAL SPACE HEATING ENERGY CONSUMPTION   = 49061 MJ     = 13628 kWh
VENTILATOR ELECTRICAL CONSUMPTION: HEATING HOURS    =     0 MJ     =     0 kWh
ESTIMATED ANNUAL DHW HEATING ENERGY CONSUMPTION     = 24889 MJ     =  6914 kWh

ESTIMATED ANNUAL SPACE + DHW ENERGY CONSUMPTION     = 73950 MJ     = 20542 kWh
ANNUAL R-2000 SPACE + DHW ENERGY CONSUMPTION TARGET = 93759 MJ     = 26044 kWh

ESTIMATED ANNUAL BASE ELECTRICAL ENERGY CONSUMPTION = 47304 MJ     = 13140 kWh
VENTILATOR ELECTRICAL CONSUMPTION: NON HEATING HOURS=     0 MJ     =     0 kWh

                *** ESTIMATED ANNUAL FUEL CONSUMPTION SUMMARY ***

FUEL                SPACE HEATING + DHW HEATING + APPLIANCES  =  TOTAL

OIL          (Litres)     1274           646           0      =  1920 Litres
ELECTRICITY  (kWh)           0             0       13140      = 13140 kWh

1 litre No. 2 Oil = 38.52 MJ or 10.7 kWh

                                ********************

     Energy units: MJ = Megajoules (3.6 MJ = 1 kWh)

     The calculated heat losses and energy consumptions are only
     estimates, based upon the data entered and assumptions within the
     program.   Actual energy consumption and heat losses will be
     influenced by construction practices, localized weather, equipment
     characteristics and the lifestyle of the occupants.
```

```
                        *** MONTHLY ENERGY PROFILE ***

MONTH    ENERGY LOAD    INTERNAL GAINS  SOLAR GAINS   AUX ENERGY REQ HRV EFF.
             MJ               MJ            MJ             MJ           %
---------------------------------------------------------------------------------
 Jan        15943            3944          2488           9512          .0
 Feb        13941            3562          2855           7523          .0
 Mar        12186            3944          3130           5112          .0
 Apr         7951            3816          1975           2160          .0
 May         4189            3263           925              0          .0
 Jun         1509            1470            39              0          .0
 Jul          902             900             1              0          .0
 Aug         1025            1021             5              0          .0
 Sep         2548            2311           237              0          .0
 Oct         5765            3741          1112            913          .0
 Nov         9345            3816          1649           3880          .0
 Dec        14125            3944          1994           8188          .0
```

APPENDIX 6.
HOT2000 simulation
Test home with 0,30 ACH ventilation
Oil heating

```
                    *****************************************
                    *                                       *
                    *               HOT-2000                *
                    *             Version 5.04              *
                    *  Energy, Mines and Resources Canada   *
                    *          September 01, 1987           *
                    *                                       *
                    *****************************************

DATE (mm/dd/yy): 01/25/91
CLIENT NAME     : MAISON BRAIS / ROUSSEL
ADDRESS         : 923 de la Pommeraie,STHILAIRE

HOUSE DATA FILENAME: pomm004
WEATHER DATA IS FOR: Montreal (Quebec)

                    *** TEMPERATURE AND BUILDING MASS ***

HEATING TEMPERATURES      MAIN FLOOR                  = 18 C
                          BASEMENT                    = 17 C
                          TEMP. SWING FROM 18 C       = .5 C

SOIL TYPE: Normal Conductivity: dry sand, loam, clay, low water table

HOUSE THERMAL MASS LEVEL: (1) Wood frame construction, 12.5 mm gyproc walls
                              and ceiling, wooden floor

              *** FOUNDATION CONSTRUCTION CHARACTERISTICS ***

FOUNDATION CONSTRUCTION     ATTACHMENT SIDES    INSULATION PLACEMENT

FULL BASEMENT                   1 SIDE               INTERIOR

                    *** WINDOW/GLAZING CHARACTERISTICS ***

ORIENTATION   AVERAGE      AVERAGE       AVERAGE   AVERAGE    AVERAGE
              # GLAZINGS   TRANSMISSION  WINDOW    OVERHANG   HEADER
                           COEFFICIENT   HEIGHT    WIDTH      HEIGHT
                                            m         m          m

Southeast       2.00           .71        1.43       .24        .04
Southwest       2.00           .70        1.37       .00        .00
Northeast       2.00           .75
Northwest       2.00           .70
```

```
                          *** BUILDING PARAMETERS ***

COMPONENT                               AREA        RSI             HEAT LOSS    % ANNUAL
                                         m2                            MJ        HEAT LOSS
-----------------------------------------------------------------------------------------

ABOVE GRADE COMPONENTS

Ceiling
                                        44.05       7.38
                                        70.10       6.98
                                          .65        .53
                         TOTAL:        114.80       6.66               6710          6.53

Main walls
                                       184.28       4.63
                                        14.98       6.94
                                         6.58        .70
                         TOTAL:        205.84       4.01              18334         17.83

Doors
                                         3.50       2.00
                                         1.75       3.00
                         TOTAL:          5.25       2.25                908           .88

Basement walls above grade
                                          .58        .70
                                        18.52       2.25
                                         2.79       3.37
                         TOTAL:         21.89       2.21               3535          3.44

FULL DEPTH BASEMENT

Upper basement walls
                                        29.37       1.11
                         TOTAL:         29.37       1.11               5208          5.06

Lower basement walls
                                        61.59       1.11
                         TOTAL:         61.59       1.11               7736          7.52

Floor perimeter
                                        43.50       1.03
                         TOTAL:         43.50       1.03               3605          3.51

Floor center
                                        54.30        .20
                         TOTAL:         54.30        .00               4905          4.77
```

WINDOWS/GLAZING		GLAZING AREA (m2)	RSI GLAZING (SHUTTER)	HEAT LOSS MJ	% ANNUAL HEAT LOSS
Southeast windows					
		7.78	.53 (.15)		
		3.00	.53 (.15)		
		.79	.36		
	TOTAL:	11.57	.51 (.13)	7780	7.57
Southwest windows					
		3.85	.53 (.15)		
	TOTAL:	3.85	.53 (.15)	2473	2.41
Northeast windows					
		5.16	.53 (.15)		
		2.53	.36		
	TOTAL:	7.69	.46 (.07)	6051	5.88
Northwest windows					
		2.28	.53 (.15)		
	TOTAL:	2.28	.53 (.15)	1465	1.42

AIR LEAKAGE AND VENTILATION	VOLUME	AIR CHANGE	HEAT LOSS MJ	% ANNUAL HEAT LOSS
	720.00 m3	.44 ACH	34405	33.46

### *** AIR LEAKAGE AND VENTILATION ***

BUILDING ENVELOPE SURFACE AREA = 561.9 m2
AIR LEAKAGE TEST RESULTS AT 50 Pa.(0.2 in. H2O) = 2.90 ACH
EQUIVALENT LEAKAGE AREA = 650 cm2
BUILDING ENVELOPE IS NOT SHELTERED FROM THE WIND.

AVERAGE VENTILATION RATE (Balanced) = .3 ACH (60 L/s)

```
VENTILATION SYSTEM IS     : Mechanical ventilator and/or fans

MANUFACTURER: no-name brand
MODEL NUMBER: xxxxx

TOTAL ELECTRICAL POWER REQUIRED                              = 0 Watts

GROSS AIR LEAKAGE AND VENTILATION ENERGY LOAD                = 34405 MJ
SEASONAL HEAT RECOVERY VENTILATOR EFFICIENCY                 =     0 %
ESTIMATED VENTILATION ELECTRICAL LOAD: HEATING HOURS         =     0 MJ
ESTIMATED VENTILATION ELECTRICAL LOAD: NON-HEATING HOURS     =     0 MJ
NET AIR LEAKAGE AND VENTILATION ENERGY LOAD                  = 34405 MJ

                          *** SPACE HEATING SYSTEM ***

PRIMARY SPACE HEATING FUEL IS : OIL
SPACE HEATING EQUIPMENT       : Furnace/boiler with flame retention head

SPACE HEATING EQUIPMENT MANUFACTURER      :
SPACE HEATING EQUIPMENT MODEL             :
SPACE HEATING EQUIPMENT OUTPUT CAPACITY   = 0 kW
MANUFACTURER'S STEADY STATE EFFICIENCY    = 86 %
DERIVED SEASONAL EFFICIENCY               = 76 %

                      *** ANNUAL SPACE HEATING SUMMARY ***

DESIGN HEAT LOSS AT  -23 C                                =  10.66 kW

GROSS SPACE HEATING LOAD                                  =102828 MJ
SENSIBLE DAILY HEAT GAIN FROM OCCUPANTS                   =  2.80 kWh/day
USABLE INTERNAL GAINS                                     = 36469 MJ
USABLE INTERNAL GAINS FRACTION                            =    35 %
USABLE SOLAR GAINS                                        = 18016 MJ
USABLE SOLAR GAINS FRACTION                               =    18 %
AUXILIARY ENERGY REQUIRED                                 = 48343 MJ
VENTILATION EQUIPMENT ELECTRICAL CONTRIBUTION             =     0 MJ
FURNACE/BOILER ANNUAL ENERGY CONSUMPTION                  = 63609 MJ

                     *** DOMESTIC WATER HEATING SYSTEM ***

PRIMARY WATER HEATING FUEL    : OIL
WATER HEATING EQUIPMENT       : Tankless coil: oil-fired

WATER HEATING EQUIPMENT MANUFACTURER      :
WATER HEATING EQUIPMENT MODEL             :
SEASONAL EFFICIENCY                       = 70 %

                  *** ANNUAL DOMESTIC WATER HEATING SUMMARY ***

DAILY HOT WATER CONSUMPTION                                 = 240 Litres/day
ESTIMATED DOMESTIC WATER HEATING LOAD                       = 17422 MJ

PRIMARY DOMESTIC WATER HEATING ENERGY CONSUMPTION           = 24889 MJ
```

```
                   *** LIGHTING AND APPLIANCES SUMMARY ***

DAILY ELECTRICAL LOAD                                        = 36 kWh/day
ESTIMATED ANNUAL ENERGY CONSUMPTION                          = 13140 kWh

         *** R-2000 HOME PROGRAM ENERGY CONSUMPTION SUMMARY REPORT ***

ESTIMATED ANNUAL SPACE HEATING ENERGY CONSUMPTION    = 63609 MJ    = 17669 kWh
VENTILATOR ELECTRICAL CONSUMPTION: HEATING HOURS     =     0 MJ    =     0 kWh
ESTIMATED ANNUAL DHW HEATING ENERGY CONSUMPTION      = 24889 MJ    =  6914 kWh

ESTIMATED ANNUAL SPACE + DHW ENERGY CONSUMPTION      = 88497 MJ    = 24583 kWh
ANNUAL R-2000 SPACE + DHW ENERGY CONSUMPTION TARGET = 93759 MJ    = 26044 kWh

ESTIMATED ANNUAL BASE ELECTRICAL ENERGY CONSUMPTION = 47304 MJ    = 13140 kWh
VENTILATOR ELECTRICAL CONSUMPTION: NON HEATING HOURS=     0 MJ    =     0 kWh

               *** ESTIMATED ANNUAL FUEL CONSUMPTION SUMMARY ***

FUEL                 SPACE HEATING + DHW HEATING + APPLIANCES  =  TOTAL

OIL           (Litres)     1651          646           0       =  2297 Litres
ELECTRICITY   (kWh)           0            0       13140       = 13140 kWh

1 litre No. 2 Oil = 38.52 MJ or 10.7 kWh

                          ********************

     Energy units: MJ = Megajoules (3.6 MJ = 1 kWh)

     The calculated heat losses and energy consumptions are only
     estimates, based upon the data entered and assumptions within the
     program.  Actual energy consumption and heat losses will be
     influenced by construction practices, localized weather, equipment
     characteristics and the lifestyle of the occupants.
```

```
                         *** MONTHLY ENERGY PROFILE ***

MONTH    ENERGY LOAD    INTERNAL GAINS  SOLAR GAINS   AUX ENERGY REQ HRV EFF.
             MJ               MJ            MJ             MJ          %
-------------------------------------------------------------------------------
 Jan        18605            3944          2747          11914         .0
 Feb        16242            3562          3016           9663         .0
 Mar        14125            3944          3430           6752         .0
 Apr         9002            3816          2254           2932         .0
 May         4491            3460          1031              0         .0
 Jun         1604            1555            49              0         .0
 Jul          933             931             2              0         .0
 Aug         1094            1087             8              0         .0
 Sep         2888            2541           346              0         .0
 Oct         6655            3869          1375           1410         .0
 Nov        10717            3816          1706           5195         .0
 Dec        16484            3944          2051          10489         .0
```

APPENDIX 7.
Master list
Monitored variables

SIRICON / CMHC / DETTSON MONITORING PROGRAM

MASTER LIST OF MONITORED VARIABLES

sensor ID	sensor type	input type	location / comments	type	status
AIR TEMP.:					
trm1	thermocpl "T"	analog	master bedroom	cont.	full dur. prg.
tliv	thermocpl "T"	analog	living room	cont.	full dur. prg.
trm2	thermocpl "T"	analog	children bedroom	cont.	full dur. prg.
trm3	thermocpl "T"	analog	office / bedroom	cont.	full dur. prg.
tret	thermocpl "T"	analog	return duct, upstream MB	cont.	full dur. prg.
trco	thermocpl "T"	analog	return duct, downstream MB	cont.	full dur. prg.
tsu1	thermocpl "T"	analog	supply downstream coil, Z#1	cont.	full dur. prg.
tsu2	thermocpl "T"	analog	supply downsteam coil, Z#2	cont.	full dur. prg.
tamb	thermocpl "T"	analog	outside air, North side	cont.	full dur. prg.
tst1	thermistr 10K	analog	Z#1 temp. at thermostat	cont.	full dur. prg.
tst2	thermistr 10K	analog	Z#2 temp. at thermostat	cont.	full dur. prg.
tbat	thermocpl "T"	analog	upper bathroom	cont.	full dur. prg.
RH AIR:					
rh1	capacitive s.	analog	return duct, upstream MB	cont	useless
rh2	capacitive s.	analog	master bedroom	cont	useless
rh3	capacitive s.	analog	upper bathroom	cont	useless
rh4	dial psyc.		near Z#1 thermostat	spot	occasional
rh5	sling psyc.		all locations, calibration	spot	occasional
AIR FLOW:					
fexh	CES Inc fms	analog	ventilation exhaust (5")	cont./spot	cancelled
fint	CES Inc fms	analog	ventilation /makeup intake (8")	cont./spot	cancelled
fhrv	CES Inc fms	analog	ventilation HRV outlet (5")	cont./spot	cancelled
fkit	CES Inc fms	analog	kitchen exhaust (6")	cont./spot	cancelled
fsu1	CES Inc fms	analog	downstream Z#1 coil (8"x15")	cont./spot	cancelled
fret	CES Inc fms	analog	upstream MB (20"x20")	cont./spot	cancelled
wind intensity	generator	analog	rotating cup anemo. on roof	cont	full dur. prg.
wind direction			St-Hubert airport met. reports		as requrd
supply distrib.	pitot		air flow to rooms / air velocity	spot	once
exh. fans	pitot		bathrooms / dryer / vacuum cl.	spot	once
HHWATER:					
thhw	thermocpl "T"	analog	heating water, boiler outlet	cont	full dur. prg.
tco1	thermocpl "T"	analog	Z#1 coil outlet	cont	full dur. prg.
tco2	thermocpl "T"	analog	Z#2 coil outlet	cont	full dur. prg.
DHWATER:					
tdhw	thermocpl "T"	analog	DHW temp. as distributed	cont	full dur. prg.
tdmu	thermocpl "T"	analog	cold water inlet temp.	cont./spot	cancelled
dhw	trident10 mtr	counter	DHW flow at boiler inlet	cont./spot	cancelled

PRESSR:					
DP1	manometer	analog	DP-attic / basement	cont	full dur. prg.
DP2	manometer	analog	DP-aver. out / basement	cont	cancelled
DP3	manometer	analog	DP-base flue / basement	cont	full dur. prg.
DP4	manometer	analog	DP-top out chimney / basement	cont	cancelled
DPD	DETTSON	analog	DP-attic / basement	cont	full dur. prg.
ENERGY					
it1	toroidal coil	analog	total house current (Amp) - ph.1	cont	cancelled
it2	toroidal coil	analog	total house current (Amp) - ph.2	cont	cancelled
ih1	toroidal coil	analog	heat. syst. current (Amp) - ph.1	cont	cancelled
ih2	toroidal coil	analog	heat. syst. current (Amp) - ph.2	cont	cancelled
iha	toroidal coil	analog	upper bathrm heater current	cont	cancelled
oil	neptune mtr	counter	burner oil flow	cont./spot	cancelled
electricity	hydro x40 mtr		total electricity consumption	spot	full dur. prg.
STATUS:					
ski	HV relay	digit.IN	exhaust fan - kitchen	cont.	full dur. prg.
sb1	HV relay	digit.IN	exhaust fan - bathroom Z#2	cont.	full dur. prg.
sb2	HV relay	digit.IN	exhaust fan - bathroom Z#1	cont.	cancelled
sdr	HV relay	digit.IN	exhaust fan - clothes dryer	cont.	full dur. prg.
svc	HV relay	digit.IN	exhaust fan - vacuum cleaner	cont.	full dur. prg.
circ1	LV relay	digit.OUT	heating circulator pump - Z#1	cont.	full dur. prg.
circ2	LV relay	digit.OUT	heating circulator pump - Z#2	cont.	full dur. prg.
sbu	LV relay	digit.OUT	burner operating status	cont.	full dur. prg.
stt1	switch	digit.IN	Z#1 thermostat status	cont.	full dur. prg.
stt2	switch	digit.IN	Z#2 thermostat status	cont.	full dur. prg.
I. AIR QUAL:					
co2	IR analyser	analog	HORIBA or ADC gaz analyser	cont.	occasional
spil1	CO / smoke		SHELTAIR detector #1	spot	occasional
spil2	CO / smoke		SHELTAIR detector #2	spot	occasional
radon	cst flow smtr		RAD Services M-1 surveymeters	spot	occasional
formaldehyde	detector tubes		AQR / ORTECH detectors	spot	occasional
ACH1	door fan		Fan depressurization method	spot	once
ACH2	BNL - AIMS		average ACH measurement	spot	occasional
ACH3	SF6		SF6 sampling in 5 places	spot	occasional
OTHERS:					
fan sound	Db meter		equipment and outlet levels	spot	occasional

APPENDIX 8.
Energy use data
Electricity consumption

DATE / TIME	METER kWh/40	DAYS	DELTA kWh	total/day kWh/day
20/7/87 19:30	19,50			
22/7/87 11:00	20,20	1,65	28	17
27/7/87 18:15	23,80	5,30	144	27
23/8/87 18:15	38,00	27,00	568	21
20/9/87 18:20	52,00	28,00	560	20
25/9/87 18:45	55,90	5,02	156	31
6/10/87 19:15	66,10	11,02	408	37
		SUM	SUM	AVER
SUMMER87:		77,99	1864	26
12/10/87 18:15	74,10	5,96	320	54
18/10/87 18:25	80,70	6,01	264	44
25/10/87 18:10	91,70	6,99	440	63
1/11/87 18:00	102,10	6,99	416	59
8/11/87 17:00	113,70	6,96	464	67
15/11/87 17:05	129,00	7,00	612	87
22/11/87 17:50	144,60	7,03	624	89
29/11/87 18:40	164,40	7,03	792	113
6/12/87 17:20	181,20	6,94	672	97
13/12/87 18:30	199,00	7,05	712	101
21/12/87 21:30	220,60	8,13	864	106
28/12/87 22:45	241,00	7,05	816	116
31/12/87 18:30	252,90	2,82	476	169
10/1/88 21:30	288,70	10,13	1432	141
20/1/88 22:15	321,70	10,03	1320	132
		SUM	SUM	AVER
WINTER87 (B):		106,13	10224	96
31/1/88 17:30	357,20	10,80	1420	131
7/2/88 16:30	382,10	6,96	996	143
14/2/88 19:00	407,50	7,10	1016	143
21/2/88 18:00	427,00	6,96	780	112
28/2/88 17:30	447,20	6,98	808	116
6/3/88 17:15	467,10	6,99	796	114
14/3/88 21:00	489,10	8,16	880	108
18/3/88 21:40	496,90	4,03	312	77
20/3/88 16:00	501,20	1,76	172	98
27/3/88 20:00	518,50	7,17	692	97
3/4/88 18:30	530,70	6,94	488	70
10/4/88 21:00	541,90	7,10	448	63
17/4/88 16:20	553,30	6,81	456	67
25/4/88 19:30	560,70	8,13	296	36
1/5/88 18:45	581,10	5,97	816	137
9/5/88 19:30	589,50	8,03	336	42
15/5/88 19:45	593,30	6,01	152	25
23/5/88 19:15	601,40	7,98	324	41

DATE / TIME	METER kWh/40	DAYS	DELTA kWh	total/day kWh/day
		SUM	SUM	AVER
WINTER88 (A):		123,88	11188	90
14/6/88 19:00	622,50	21,99	844	38
17/6/88 21:00	624,60	3,08	84	27
26/6/88 19:00	630,80	8,92	248	28
10/7/88 19:30	641,20	14,02	416	30
24/7/88 20:00	650,40	14,02	368	26
8/8/88 17:00	661,60	14,88	448	30
22/8/88 22:30	672,80	14,23	448	31
6/9/88 22:30	683,30	15,00	420	28
		SUM	SUM	AVER
SUMMER88:		106,14	3276	30
16/10/88 19:30	732,00	39,88	1948	49
31/10/88 20:00	750,80	15,02	752	50
4/12/88 16:00	848,90	33,83	3924	116
11/12/88 18:00	863,40	7,08	580	82
24/12/88 21:00	910,50	13,13	1884	144
11/1/89 20:00	969,50	17,96	2360	131
14/1/89 11:00	971,50	2,63	80	30
20/1/89 17:20	978,00	6,26	260	42
		SUM	SUM	AVER
WINTER88 (B):		135,78	11788	80
5/2/89 17:00	991,50	15,99	540	34
13/2/89 20:45	998,10	8,16	264	32
21/2/89 18:00	1005,00	7,89	276	35
26/2/89 20:15	1010,10	5,09	204	40
8/3/89 18:00	1019,00	9,91	356	36
11/3/89 15:00	1022,00	2,88	120	42
19/3/89 17:00	1029,00	8,08	280	35
9/4/89 17:00	1049,50	21,00	820	39
25/4/89 21:00	1064,00	16,17	580	36
7/5/89 18:15	1074,50	11,89	420	35
17/5/89 19:30	1083,50	10,05	360	36
		SUM	SUM	AVER
WINTER89 (A):		117,09	4220	36
9/6/89 9:30	1104,30	22,58	832	37
12/6/89 16:00	1107,50	3,27	128	39
17/7/89 8:15	1132,80	34,68	1012	29
26/7/89 8:00	1141,00	8,99	328	36
4/10/89 19:30	1202,00	70,48	2440	35
		SUM	SUM	AVER
SUMMER89:		140,00	4740	35

DATE / TIME	METER kWh/40	DAYS	DELTA kWh	total/day kWh/day
2/11/89 22:30	1230,50	29,13	1140	39
6/11/89 21:00	1234,80	3,94	172	44
12/11/89 22:30	1241,10	6,06	252	42
20/11/89 23:30	1250,50	8,04	376	47
6/12/89 19:30	1268,30	15,83	712	45
14/12/89 18:30	1278,00	7,96	388	49
15/12/89 20:45	1279,10	1,09	44	40
16/12/89 20:30	1280,50	0,99	56	57
17/12/89 22:00	1282,00	1,06	60	56
18/12/89 22:30	1283,00	1,02	40	39
20/12/89 22:30	1285,10	2,00	84	42
22/12/89 23:00	1287,80	2,02	108	53
23/12/89 20:00	1289,00	0,88	48	55
24/12/89 21:00	1290,00	1,04	40	38
28/12/89 20:30	1293,70	3,98	148	37
29/12/89 22:30	1295,00	1,08	52	48
30/12/89 22:30	1296,00	1,00	40	40
31/12/89 20:45	1296,80	0,93	32	35
1/1/90 19:30	1297,80	0,95	40	42
2/1/90 20:30	1299,00	1,04	48	46
3/1/90 23:15	1300,00	1,11	40	36
4/1/90 20:00	1300,90	0,86	36	42
5/1/90 21:00	1302,10	1,04	48	46
7/1/90 22:30	1304,60	2,06	100	48
8/1/90 22:00	1305,50	0,98	36	37
9/1/90 23:00	1306,60	1,04	44	42
10/1/90 21:30	1307,60	0,94	40	43
11/1/90 22:30	1308,80	1,04	48	46
12/1/90 21:30	1309,80	0,96	40	42
14/1/90 21:30	1312,20	2,00	96	48
15/1/90 21:00	1313,30	0,98	44	45
16/1/90 21:00	1314,30	1,00	40	40
17/1/90 21:00	1315,40	1,00	44	44
18/1/90 20:00	1316,50	0,96	44	46
19/1/90 21:45	1317,70	1,07	48	45
20/1/90 22:30	1318,80	1,03	44	43
		SUM	**SUM**	**AVER**
WINTER89 (B):		108,13	4672	44
21/1/90 23:00	1320,20	1,02	56	55
22/1/90 21:30	1321,20	0,94	40	43
24/1/90 21:30	1323,40	2,00	88	44
25/1/90 23:30	1324,50	1,08	44	41
26/1/90 21:30	1325,50	0,92	40	44
27/1/90 20:30	1326,50	0,96	40	42
28/1/90 20:30	1327,60	1,00	44	44
29/1/90 21:30	1328,90	1,04	52	50

DATE / TIME	METER kWh/40	DAYS	DELTA kWh	total/day kWh/day
30/1/90 21:30	1329,90	1,00	40	40
31/1/90 21:00	1330,90	0,98	40	41
1/2/90 23:00	1332,30	1,08	56	52
4/2/90 0:15	1334,40	2,05	84	41
13/2/90 17:00	1345,00	9,70	424	44
21/2/90 21:30	1354,10	8,19	364	44
4/3/90 20:45	1366,40	10,97	492	45
21/3/90 22:15	1385,30	17,06	756	44
24/3/90 17:00	1388,10	2,78	112	40
7/4/90 17:00	1404,40	14,00	652	47
18/5/90 22:00	1445,60	41,21	1648	40
		SUM	**SUM**	**AVER**
WINTER90 (A):		117,98	5072	44

APPENDIX 9.
Energy use data
Oil consumption

DATE / TIME	METER liters	DAYS	DELTA liters	PERDIEM liters/day	ENERGY kWh	E.P.D. kWh/day
20/1/89 17:20	119					
5/2/89 23:00	314	16,24	195	12,01	2087	129
13/2/89 20:45	407	7,91	93	11,76	995	126
21/2/89 20:00	496	7,97	89	11,17	952	120
26/2/39 20:15	551	5,01	55	10,98	589	117
7/3/89 20:00	659	8,99	108	12,01	1156	129
11/3/89 11:50	701	3,66	42	11,48	449	123
19/3/89 17:00	769	8,22	68	8,28	728	89
2/4/89 21:00	887	14,17	118	8,33	1263	89
9/4/89 20:45	933	21,16	46	2,17	492	23
24/4/89 22:30	1065	15,07	132	8,76	1412	94
7/5/89 21:15	1137	12,95	72	5,56	770	59
17/5/89 20:45	1180	9,98	43	4,31	460	46
		SUM	SUM	AVER	SUM	AVER
WINTER89 (A):		131,31	1061	8,90	11353	95
9/6/89 11:00	1262	22,59	82	3,63	877	39
12/6/89 17:30	1278	3,27	16	4,89	171	52
17/7/89 8:15	1346	34,61	68	1,96	728	21
26/7/89 8:00	1366	8,99	20	2,22	214	24
4/10/89 19:30	1541	70,48	175	2,48	1873	27
		SUM	SUM	AVER	SUM	AVER
SUMMER89:		139,95	361	3,04	3863	33
2/11/89 22:30	1661	29,13	120	4,12	1284	44
6/11/89 21:00	1686	3,94	25	6,35	268	68
12/11/89 22:30	1720	6,06	34	5,61	364	60
20/11/89 23:30	1792	8,04	72	8,95	770	96
6/12/89 19:30	2035	15,83	243	15,35	2600	164
14/12/89 18:30	2175	7,96	140	17,59	1498	188
15/12/89 20:45	2197	1,09	22	20,11	235	215
16/12/89 20:30	2218	0,99	21	21,22	225	227
17/12/89 22:00	2237	1,06	19	17,88	203	191
18/12/89 22:30	2255	1,02	18	17,63	193	189
20/12/89 22:30	2292	2,00	37	18,50	396	198
22/12/89 20:00	2331	1,90	39	20,57	417	220
23/12/89 20:00	2350	1,00	19	19,00	203	203
24/12/89 21:00	2371	1,04	21	20,16	225	216
28/12/89 20:30	2434	3,98	63	15,83	674	169
29/12/89 22:30	2453	1,08	19	17,54	203	188
30/12/89 22:30	2470	1,00	17	17,00	182	182
31/12/89 20:45	2484	0,93	14	15,10	150	162
1/1/90 19:30	2497	0,95	13	13,71	139	147
2/1/90 20:30	2511	1,04	14	13,44	150	144
3/1/90 23:15	2523	1,11	12	10,77	128	115
4/1/90 20:00	2534	0,86	11	12,72	118	136

DATE / TIME	METER liters	DAYS	DELTA liters	PERDIEM liters/day	ENERGY kWh	E.P.D. kWh/day
5/1/90 21:00	2543	1,04	9	8,64	96	92
7/1/90 22:30	2578	2,06	35	16,97	375	182
8/1/90 22:00	2586	0,98	8	8,17	86	87
9/1/90 23:00	2598	1,04	12	11,52	128	123
10/1/90 21:30	2609	0,94	11	11,73	118	126
11/1/90 22:30	2623	1,04	14	13,44	150	144
12/1/90 21:30	2633	0,96	10	10,43	107	112
14/1/90 21:30	2666	2,00	33	16,50	353	177
15/1/90 21:00	2685	0,98	19	19,40	203	208
16/1/90 21:00	2700	1,00	15	15,00	161	161
17/1/90 21:00	2713	1,00	13	13,00	139	139
18/1/90 20:00	2721	0,96	8	8,35	86	89
19/1/90 21:45	2735	1,07	14	13,05	150	140
20/1/90 22:30	2749	1,03	14	13,58	150	145
		SUM	SUM	AVER	SUM	AVER
WINTER89 (B):		108,13	1208	14,14	12926	151
21/1/90 23:00	2771	1,02	22	21,55	235	231
22/1/90 21:30	2788	0,94	17	18,13	182	194
24/1/90 21:30	2812	2,00	24	12,00	257	128
25/1/90 23:30	2821	1,08	9	8,31	96	89
26/1/90 21:30	2833	0,92	12	13,09	128	140
27/1/90 20:30	2843	0,96	10	10,43	107	112
28/1/90 20:30	2854	1,00	11	11,00	118	118
29/1/90 21:30	2868	1,04	14	13,44	150	144
30/1/90 21:30	2880	1,00	12	12,00	128	128
31/1/90 21:00	2890	0,98	10	10,21	107	109
1/2/90 23:00	2901	1,08	11	10,15	118	109
4/2/90 0:15	2934	2,05	33	16,08	353	172
4/2/90 20:40	2950	0,85	16	18,81	171	201
5/2/90 21:15	2966	1,02	16	15,62	171	167
6/2/90 22:30	2979	1,05	13	12,36	139	132
7/2/90 22:00	2991	0,98	12	12,26	128	131
8/2/90 22:00	3003	1,00	12	12,00	128	128
10/2/90 22:00	3021	2,00	18	9,00	193	96
11/2/90 22:00	3033	1,00	12	12,00	128	128
12/2/90 21:00	3042	0,96	9	9,39	96	100
13/2/90 21:00	3056	1,00	14	14,00	150	150
14/2/90 22:30	3066	1,06	10	9,41	107	101
16/2/90 0:00	3084	1,06	18	16,94	193	181
16/2/90 23:00	3099	0,96	15	15,65	161	167
18/2/90 1:05	3111	1,09	12	11,04	128	118
18/2/90 22:00	3127	0,87	16	18,36	171	196
19/2/90 23:45	3138	1,07	11	10,25	118	110
21/2/90 21:30	3167	1,91	29	15,21	310	163
22/2/90 21:30	3177	1,00	10	10,00	107	107
23/2/90 21:00	3188	0,98	11	11,23	118	120

DATE / TIME	METER liters	DAYS	DELTA liters	PERDIEM liters/day	ENERGY kWh	E.P.D. kWh/day
24/2/90 21:35	3203	1,02	15	14,64	161	157
25/2/90 20:45	3220	0,97	17	17,61	182	188
26/2/90 22:00	3238	1,05	18	17,11	193	183
27/2/90 21:30	3257	0,98	19	19,40	203	208
28/2/90 22:00	3269	1,02	12	11,76	128	126
1/3/90 23:00	3285	1,04	16	15,36	171	164
2/3/90 23:00	3291	1,00	6	6,00	64	64
3/3/90 21:45	3302	0,95	11	11,60	118	124
4/3/90 20:45	3316	0,96	14	14,61	150	156
5/3/90 23:00	3330	1,09	14	12,80	150	137
6/3/90 20:45	3345	0,91	15	16,55	161	177
7/3/90 21:00	3356	1,01	11	10,89	118	116
8/3/90 21:00	3368	1,00	12	12,00	128	128
9/3/90 21:30	3374	1,02	6	5,88	64	63
10/3/90 20:30	3382	0,96	8	8,35	86	89
11/3/90 23:40	3388	1,13	6	5,30	64	57
12/3/90 20:40	3394	0,88	6	6,86	64	73
13/3/90 21:30	3402	1,03	8	7,73	86	83
14/3/90 23:00	3411	1,06	9	8,47	96	91
15/3/90 21:30	3416	0,94	5	5,33	54	57
16/3/90 21:00	3422	0,98	6	6,13	64	66
17/3/90 21:00	3425	1,00	3	3,00	32	32
18/3/90 21:53	3432	1,04	7	6,75	75	72
19/3/90 20:30	3438	0,94	6	6,37	64	68
20/3/90 21:22	3448	1,04	10	9,65	107	103
21/3/90 22:15	3455	1,04	7	6,75	75	72
22/3/90 20:20	3463	0,92	8	8,69	86	93
23/3/90 23:35	3470	1,14	7	6,17	75	66
24/3/90 21:17	3477	0,90	7	7,74	75	83
25/3/90 21:03	3490	0,99	13	13,13	139	140
26/3/90 21:00	3499	1,00	9	9,02	96	97
27/3/90 20:10	3510	0,97	11	11,40	118	122
29/3/90 20:10	3528	2,00	18	9,00	193	96
30/3/90 19:30	3540	0,97	12	12,34	128	132
1/4/90 20:30	3555	2,04	15	7,35	161	79
2/4/90 18:45	3562	0,93	7	7,55	75	81
3/4/90 20:00	3571	1,05	9	8,55	96	92
4/4/90 19:00	3582	0,96	11	11,48	118	123
5/4/90 19:45	3589	1,03	7	6,79	75	73
6/4/90 21:30	3597	1,07	8	7,46	86	80
7/4/90 17:00	3603	0,81	6	7,38	64	79
8/4/90 21:50	3613	1,20	10	8,32	107	89
9/4/90 20:50	3620	0,96	7	7,30	75	78
10/4/90 18:25	3625	0,90	5	5,56	54	59
11/4/90 22:00	3639	1,15	14	12,18	150	130
15/4/90 19:50	3665	3,91	26	6,65	278	71
16/4/90 20:30	3671	1,03	6	5,84	64	62

DATE / TIME	METER liters	DAYS	DELTA liters	PERDIEM liters/day	ENERGY kWh	E.P.D. kWh/day
17/4/90 20:20	3679	0,99	8	8,06	86	86
18/4/90 20:00	3687	0,99	8	8,11	86	87
20/4/90 20:30	3699	2,02	12	5,94	128	64
22/4/90 20:00	3708	1,98	9	4,55	96	49
24/4/90 20:00	3717	2,00	9	4,50	96	48
25/4/90 20:00	3721	1,00	4	4,00	43	43
9/5/90 20:40	3784	14,03	63	4,49	674	48
14/5/90 20:50	3803	5,01	19	3,79	203	41
15/5/90 21:35	3807	1,03	4	3,88	43	42
17/5/90 20:20	3814	1,95	7	3,59	75	38
18/5/90 22:00	3817	1,07	3	2,81	32	30
		SUM	SUM	AVER	SUM	AVER
WINTER90 (A):		117,98	1068	10,12	11428	108

APPENDIX 10.
Energy use data
Hot water consumption

HOT WATER CONSUMPTION

APPENDIX 10

DATE/TIME	METER cu.m.	DAYS	DELTA cu.m.	Tcold oC	ENERGY kWh	ENERGY kWh/day	PERDIEM cu.m./day
20/1/89 17:22	2,85						
5/2/89 23:00	5,70	16,23	2,85	4	186	11	0,18
13/2/89 20:45	7,45	7,91	1,75	4	114	14	0,22
21/2/89 20:00	8,80	7,97	1,35	4	88	11	0,17
26/2/89 20:15	9,90	5,01	1,10	4	72	14	0,22
7/3/89 20:00	12,40	8,99	2,50	6	157	17	0,28
11/3/89 11:50	13,60	3,66	1,20	6	75	21	0,33
19/3/89 17:00	14,90	8,22	1,30	6	82	10	0,16
2/4/89 21:00	18,40	14,17	3,50	8	212	15	0,25
9/4/89 20:45	19,70	6,99	1,30	8	79	11	0,19
24/4/89 22:30	22,60	15,07	2,90	8	175	12	0,19
7/5/89 21:15	25,50	12,95	2,90	10	169	13	0,22
17/5/89 20:45	27,60	9,98	2,10	10	122	12	0,21
		SUM	SUM		SUM	AVER	AVER
WINTER89 (A):		117,14	24,75		1530	14	0,22
9/6/89 11:00	33,96	22,59	6,36	12	355	16	0,28
12/6/89 17:30	35,34	3,27	1,38	12	77	24	0,42
17/7/89 8:15	39,10	34,61	3,76	12	210	6	0,11
26/7/89 8:00	40,40	8,99	1,30	12	73	8	0,14
4/10/89 19:30	50,60	70,48	10,20	8	617	9	0,14
		SUM	SUM		SUM	AVER	AVER
SUMMER89:		139,95	23,00		1331	12	0,22
2/11/89 22:30	56,15	29,13	5,55	6	349	12	0,19
6/11/89 21:00	57,00	3,94	0,85	6	53	14	0,22
12/11/89 22:30	57,80	6,06	0,80	6	50	8	0,13
20/11/89 23:30	60,40	8,04	2,60	6	163	20	0,32
6/12/89 19:30	62,85	15,83	2,45	4	160	10	0,15
14/12/89 18:30	64,90	7,96	2,05	4	134	17	0,26
15/12/89 20:45	65,10	1,09	0,20	4	13	12	0,18
16/12/89 20:30	65,30	0,99	0,20	4	13	13	0,20
17/12/89 22:00	65,50	1,06	0,20	4	13	12	0,19
18/12/89 22:30	65,80	1,02	0,30	4	20	19	0,29
20/12/89 22:30	66,30	2,00	0,50	4	33	16	0,25
22/12/89 23:00	66,70	2,02	0,40	4	26	13	0,20
23/12/89 20:00	67,00	0,88	0,30	4	20	22	0,34
24/12/89 21:00	67,30	1,04	0,30	4	20	19	0,29
28/12/89 20:30	67,60	3,98	0,30	4	20	5	0,08
29/12/89 22:30	68,00	1,08	0,40	4	26	24	0,37
30/12/89 22:30	68,30	1,00	0,30	4	20	20	0,30
31/12/89 20:45	68,40	0,93	0,10	4	7	7	0,11
1/1/90 19:30	68,90	0,95	0,50	4	33	34	0,53
2/1/90 20:30	69,10	1,04	0,20	4	13	13	0,19
3/1/90 23:15	69,20	1,11	0,10	4	7	6	0,09
4/1/90 20:00	69,60	0,86	0,40	4	26	30	0,46

DATE/TIME	METER cu.m.	DAYS	DELTA cu.m.	Tcold oC	ENERGY kWh	ENERGY kWh/day	PERDIEM cu.m./day
5/1/90 21:00	69,70	1,04	0,10	4	7	6	0,10
7/1/90 22:30	70,50	2,06	0,80	4	52	25	0,39
8/1/90 22:00	70,60	0,98	0,10	4	7	7	0,10
9/1/90 23:00	70,90	1,04	0,30	4	20	19	0,29
10/1/90 21:30	71,00	0,94	0,10	4	7	7	0,11
11/1/90 22:30	71,20	1,04	0,20	4	13	13	0,19
12/1/90 21:30	71,40	0,96	0,20	4	13	14	0,21
14/1/90 21:30	72,00	2,00	0,60	4	39	20	0,30
15/1/90 21:00	72,30	0,98	0,30	4	20	20	0,31
16/1/90 21:00	72,40	1,00	0,10	4	7	7	0,10
17/1/90 21:00	72,70	1,00	0,30	4	20	20	0,30
18/1/90 20:00	72,90	0,96	0,20	4	13	14	0,21
19/1/90 21:45	73,10	1,07	0,20	4	13	12	0,19
20/1/90 22:30	73,30	1,03	0,20	4	13	13	0,19
		SUM	SUM		SUM	AVER	AVER
WINTER89 (B):		108,13	22,70		1456	15	0,23
21/1/90 23:00	73,80	1,02	0,50	4	33	32	0,49
22/1/90 21:30	74,10	0,94	0,30	4	20	21	0,32
24/1/90 21:30	74,50	2,00	0,40	4	26	13	0,20
25/1/90 23:30	74,70	1,08	0,20	4	13	12	0,18
26/1/90 21:30	75,00	0,92	0,30	4	20	21	0,33
27/1/90 20:30	75,20	0,96	0,20	4	13	14	0,21
28/1/90 20:30	75,50	1,00	0,30	4	20	20	0,30
29/1/90 21:30	75,80	1,04	0,30	4	20	19	0,29
30/1/90 21:30	76,10	1,00	0,30	4	20	20	0,30
31/1/90 21:00	76,20	0,98	0,10	4	7	7	0,10
1/2/90 23:00	76,60	1,08	0,40	4	26	24	0,37
4/2/90 0:15	77,10	2,05	0,50	4	33	16	0,24
4/2/90 20:40	77,30	0,85	0,20	4	13	15	0,24
5/2/90 21:15	77,50	1,02	0,20	4	13	13	0,20
6/2/90 22:30	77,80	1,05	0,30	4	20	19	0,29
7/2/90 22:00	78,00	0,98	0,20	4	13	13	0,20
8/2/90 22:00	78,30	1,00	0,30	4	20	20	0,30
10/2/90 22:00	78,70	2,00	0,40	4	26	13	0,20
11/2/90 22:00	78,90	1,00	0,20	4	13	13	0,20
12/2/90 21:00	79,10	0,96	0,20	4	13	14	0,21
13/2/90 21:00	79,30	1,00	0,20	4	13	13	0,20
14/2/90 22:30	79,50	1,06	0,20	4	13	12	0,19
16/2/90 0:00	79,70	1,06	0,20	4	13	12	0,19
16/2/90 23:00	79,90	0,96	0,20	4	13	14	0,21
18/2/90 1:05	80,40	1,09	0,50	4	33	30	0,46
18/2/90 22:00	80,60	0,87	0,20	4	13	15	0,23
19/2/90 23:45	80,90	1,07	0,30	4	20	18	0,28
21/2/90 21:30	81,30	1,91	0,40	4	26	14	0,21
22/2/90 21:30	81,50	1,00	0,20	4	13	13	0,20
23/2/90 21:00	81,80	0,98	0,30	4	20	20	0,31

DATE/TIME	METER cu.m.	DAYS	DELTA cu.m.	Tcold oC	ENERGY kWh	ENERGY kWh/day	PERDIEM cu.m./day
24/2/90 21:35	82,00	1,02	0,20	4	13	13	0,20
25/2/90 20:45	82,30	0,97	0,30	4	20	20	0,31
26/2/90 22:00	82,40	1,05	0,10	4	7	6	0,10
27/2/90 21:30	82,70	0,98	0,30	4	20	20	0,31
28/2/90 22:00	82,90	1,02	0,20	4	13	13	0,20
1/3/90 23:00	83,20	1,04	0,30	6	19	18	0,29
2/3/90 23:00	83,30	1,00	0,10	6	6	6	0,10
3/3/90 21:45	83,70	0,95	0,40	6	25	27	0,42
4/3/90 20:45	84,10	0,96	0,40	6	25	26	0,42
5/3/90 23:00	84,20	1,09	0,10	6	6	6	0,09
6/3/90 20:45	84,60	0,91	0,40	6	25	28	0,44
7/3/90 21:00	84,80	1,01	0,20	6	13	12	0,20
8/3/90 21:00	85,20	1,00	0,40	6	25	25	0,40
9/3/90 21:30	85,30	1,02	0,10	6	6	6	0,10
10/3/90 20:30	85,60	0,96	0,30	6	19	20	0,31
11/3/90 23:40	85,80	1,13	0,20	6	13	11	0,18
12/3/90 20:40	86,20	0,88	0,40	6	25	29	0,46
13/3/90 21:30	86,40	1,03	0,20	6	13	12	0,19
14/3/90 23:00	86,80	1,06	0,40	6	25	24	0,38
15/3/90 21:30	87,00	0,94	0,20	6	13	13	0,21
16/3/90 21:00	87,20	0,98	0,20	6	13	13	0,20
17/3/90 21:00	87,50	1,00	0,30	6	19	19	0,30
18/3/90 21:50	87,90	1,03	0,40	6	25	24	0,39
19/3/90 20:30	88,20	0,94	0,30	6	19	20	0,32
20/3/90 21:20	88,50	1,03	0,30	6	19	18	0,29
21/3/90 22:15	88,80	1,04	0,30	6	19	18	0,29
22/3/90 20:20	89,10	0,92	0,30	6	19	20	0,33
23/3/90 23:30	89,20	1,13	0,10	6	6	6	0,09
24/3/90 21:20	89,40	0,91	0,20	6	13	14	0,22
25/3/90 21:00	89,90	0,99	0,50	6	31	32	0,51
26/3/90 21:00	90,10	1,00	0,20	6	13	13	0,20
27/3/90 20:10	90,30	0,97	0,20	6	13	13	0,21
29/3/90 20:10	90,90	2,00	0,60	6	38	19	0,30
30/3/90 19:30	91,20	0,97	0,30	6	19	19	0,31
1/4/90 20:30	92,10	2,04	0,90	8	54	27	0,44
2/4/90 18:45	92,40	0,93	0,30	8	18	20	0,32
3/4/90 20:00	92,80	1,05	0,40	8	24	23	0,38
4/4/90 19:00	93,30	0,96	0,50	8	30	32	0,52
5/4/90 19:45	93,40	1,03	0,10	8	6	6	0,10
6/4/90 21:30	93,70	1,07	0,30	8	18	17	0,28
7/4/90 17:00	93,80	0,81	0,10	8	6	7	0,12
8/4/90 21:50	94,50	1,20	0,70	8	42	35	0,58
9/4/90 20:50	94,80	0,96	0,30	8	18	19	0,31
10/4/90 18:20	95,10	0,90	0,30	8	18	20	0,33
11/4/90 22:00	95,30	1,15	0,20	8	12	10	0,17
15/4/90 19:50	96,00	3,91	0,70	8	42	11	0,18
16/4/90 20:30	96,20	1,03	0,20	8	12	12	0,19

DATE/TIME	METER cu.m.	DAYS	DELTA cu.m.	Tcold oC	ENERGY kWh	ENERGY kWh/day	PERDIEM cu.m./day
17/4/90 20:20	96,70	0,99	0,50	8	30	30	0,50
18/4/90 20:00	96,90	0,99	0,20	8	12	12	0,20
20/4/90 20:30	97,70	2,02	0,80	8	48	24	0,40
22/4/90 20:00	98,20	1,98	0,50	8	30	15	0,25
24/4/90 20:00	98,90	2,00	0,70	8	42	21	0,35
25/4/90 20:00	99,30	1,00	0,40	8	24	24	0,40
9/5/90 20:40	104,10	14,03	4,80	10	279	20	0,34
14/5/90 20:50	105,40	5,01	1,30	10	76	15	0,26
15/5/90 21:35	105,70	1,03	0,30	10	17	17	0,29
17/5/90 20:20	106,20	1,95	0,50	10	29	15	0,26
18/5/90 22:00	106,30	1,07	0,10	10	6	5	0,09
		SUM	SUM		SUM	AVER	AVER
WINTER90 (A):		117,98	33,00		2043	17	0,27